To the Medical Society of London
from the Author
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MEDICAL SOCIETY OF LONDON

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INAUGURAL DISSERTATION

ON THE

PHYSIOLOGY AND PATHOLOGY

OF THE

BRAIN:

BEING AN ATTEMPT TO ASCERTAIN WHAT PORTIONS OF THAT ORGAN ARE MORE IMMEDIATELY CONNECTED WITH MOTION, SENSATION, AND INTELLIGENCE,

SUBMITTED TO

The Medical Faculty of the University of Edinburgh,

IN CONFORMITY WITH THE RULES FOR GRADUATION,

BY AUTHORITY OF

THE VERY REV. PRINCIPAL BAIRD,

AND WITH THE SANCTION OF

THE SENATUS ACADEMICUS,

BY

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TO

WILLIAM KINGDON, Esq.

OF LONDON,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS, &c. &c.

THIS ESSAY

IS DEDICATED

AS A MARK OF RESPECT AND ESTEEM

FOR HIS PROFESSIONAL TALENTS

AND PRIVATE VIRTUES,

AND

AS A TRIFLING ACKNOWLEDGMENT

FOR THE NUMEROUS ACTS OF KINDNESS

HE HAS CONFERRED

ON HIS SINCERE FRIEND,

THE AUTHOR.

PREFACE.

The following Essay is divided into Two Parts :—The First, gives a short abstract of the more important physiological and pathological facts with which we are acquainted, and exhibits how opposed to each other are the different theories deduced from them.* The Second, contains the conclusions the author has derived from the whole, with such arguments as, in his opinion, appear sufficient to warrant their being entertained.

A short account of the opinions and discoveries of the older writers has been added in the form of Introduction. It has been compiled from the different histories of medicine, and biographical memoirs; where these, however, have been deficient, the originals were consulted. The author hopes that this portion of the Essay will, as a matter of reference, be useful to some of his readers.

John Hughes Bennett.

July, 1837.

* The first part of the Essay is founded on a paper read to the Royal Medical Society of Edinburgh, January 8, 1836.

CONTENTS.

ESSAY.

HISTORICAL INTRODUCTION.

Pythagoras, who flourished about 600 years before Christ, was the first, as far as I can discover, who is recorded to have attributed any function to the brain. According to him, this organ was destined to be the seat of the soul. The soul he divided into two portions, the rational and the irrational; the former he placed in the brain, the latter in the heart: the first he considered immortal, the last perishable. The rational, he imagined, after death passed into the regions of the dead, where it remained till it was sent back to the world to be the inhabitant of some other body,—brutal or human; and that, after suffering successive purifications, it was received among the gods, and returned to the eternal source from whence it first proceeded.

Timæus Locras, a celebrated Pythagorean philosopher and contemporary, although he has treated in his work, "De Animâ Mundi," of the different functions of the body, with regard to the nervous system has little to say. He calls the brain "the seat of the soul," and says that it is "the origin and root of the medulla, and that a process extends from it through the vertebræ of the back."

Alcmæon, a disciple of Pythagoras, is said to have been the first who attempted the dissection of a dead body, but there are strong grounds for believing that his anatomy was confined to the lower animals. He discovered the cochlea, and said that hearing resulted from the concave form of the interior of the ear, all hollow places resounding when any noise entered them. He imagined the brain to be the seat of the soul, which is in perpe-

tual motion and immortal. He supposed it to receive the odours inhaled in respiration, thus producing the sense of smell, while, by means of its humidity, moderate heat, and softness, the tongue was enabled to discriminate tastes.

The absurd opinions held by these philosophers regarding the structure and functions of the brain, were not destined to receive any material improvement, even from the acute mind of Hippocrates. The knowledge of this individual, although it threw light upon almost every subject connected with medicine, was necessarily limited by the prejudices of the time in which he lived, when the human body had hitherto never been dissected. His acquaintance with human structure could only be derived from accident, or by a comparison with that of other animals. Hence the whole of his physiological doctrines are unworthy of any serious regard. Concerning the brain, it does not appear that Hippocrates had the least suspicion of its connexion with sensibility and understanding; indeed, so far from considering it as the peculiar seat of the thinking faculty, he places it in the left ventricle of the heart. He speaks of it merely as a gland,* which he says it resembles in texture. According to him, it serves as a receptacle for the redundant moisture, which is afterwards discharged in a fluid state through the ears, eyes, nose—sometimes into the fauces, gullet, and medulla spinalis. To the retention or immoderate discharge of this fluid, he ascribes those diseases termed by us mental, the one causing apoplexy, the other, hallucinations of mind. He also considered the brain to be an organ of reproduction, for he states that the semen was eliminated and prepared in it, and conveyed by the spinal marrow to the vessels provided for its reception. Hippocrates knew nothing distinctly concerning the nature and uses of the nerves, though he seems to have had some confused notions respecting the nervous power, which however he places in the veins. If the spirit, he says,† which flows through the veins, be stopped or interrupted, the part in which it is stopped becomes impotent; thus in sitting or lying down, when the veins are compressed so that the spirit does not pass through them, a torpor is immediately induced.

Polybus, a disciple of Hippocrates, was the reputed author of many books that now appear under the name of that physician.

* Lib. de Glandulis. † De Locis in Homini.

It is probable that the book "De Glandulis" is one of these, as we know from Galen that Polybus wrote a work on the nature of the semen, in which he adopted the same views as Hippocrates.

Plato considered the brain as the seat of the governing principle,* but he has shewn himself ignorant of the proper distinction between nerves, tendons, and ligaments. In his Thætetus, however, he has treated of the philosophy of sensation with such precision, as proves that he had formed a distinct conception of its nature, although he was but imperfectly acquainted with the instruments which convey it to the mind. In the Phædo, Socrates says, "I gave myself up in the earlier part of my life to the study of nature with great ardour; and amongst other things, was anxious to know whether we have sense and intelligence by the blood, or by fire, or by air; or whether the senses of hearing, seeing, and smelling, depend upon the *brain*."

The celebrated philosopher, Aristotle, appears to have had very erroneous notions concerning the anatomy and physiology of the brain. He thought this organ was nothing but a mass of earth and water, void of blood, and destitute of sensation, whose only office was to balance and correct the heat of the heart. This he agreed with Hippocrates in considering the seat of sensation and all the intellectual faculties; though some, he says, are of opinion that the powers of perceiving and feeling are in the brain. He laid it down as a maxim, that man has the largest brain of all animals in proportion to the size of his body; and this, though now proved to be erroneous, has been almost universally received from his own time to the present day. He confounded the nerves with the tendons and ligaments, and ascribed the origin of them to the heart. His abstract ideas regarding the soul, however, are more philosophical:—"Some improperly call fire or some such principle the soul. It would be better to say that the soul exists *in* such a substance, because fire is the body most subservient to her operations. For, to nourish and move are the operations of the soul, and these she performs by the instrumentality of this principle. To say that the soul is fire, is as if one were to call a saw or a wimble the artificer, or his art, because his work is performed along with them. Hence it appears why animals stand in need of heat."†

Under the Ptolemies of Egypt flourished two celebrated ana-

* Plato, Tim. Loc. de Animâ Mundi.

† De Partibus Animalium, lib. ii. c. 7.

tomists, Herophilus and Erasistratus, who were the first, as far as authentic records go, who dissected the human subject. It is not to be supposed that so important an organ as the brain could escape their notice ; and, accordingly, we find that they were the first also who properly investigated its nature, and attributed to it and the nerves their proper function. For these reasons, their opinions demand some consideration.

Herophilus looked upon the brain as the seat of the soul, which resided in one of its ventricles, and as the sensorium, or source of all the vital actions and sensations. The cavity of the fourth ventricle of the brain he compared to that of a pen. The point where all the sinuses meet he termed *ληνος*, or wine-press, which retains the denomination to this day, with the addition of his name, being now called torcular herophili. He also first named the tela choroidea. The discovery of the true nerves, which were unknown both to Hippocrates and Aristotle, is ascribed with much apparent plausibility to Herophilus, who arranged them in three divisions. The first consisted of those real nerves which originated in the substance of the cerebrum, cerebellum, or spinal marrow. These he considered the organs of motion and sensation throughout the system, having found that those which communicated sensation, and obeyed the commands of the will, could be traced either to the encephalon itself, or to the spinal marrow, which is but a continuation of it. What he arranged as nerves under the two remaining divisions, were evidently nothing more than the tendons and ligaments. He particularly described the optic nerves, or, as he called them, the optic pores, which had, he maintained, a perceptible cavity, not observable in any of the other nerves.

Erasistratus gave a very complete and clear account of the appearances presented by the cerebrum, cerebellum and nerves, upon dissection. "We examined," says he, "what the nature of the human brain was, and we found it divided into two parts, as in all other animals. Each had a ventricle or cavity of a longitudinal form ; these ventricles had a communication with each other, and terminated in a common opening, according to the contiguity of their parts, reaching afterwards to the cerebellum, where there was also a small cavity ; and the cerebellum in particular was wrapped up by itself, as well as the brain, which, by its various windings and turnings, resembled the intestinum jejunum. The cerebellum was in like manner folded and twisted

different ways, so that it was easy to know by seeing it, that as in the legs of swift running animals, as in the deer, the horse, and some others, we observe the tendons and muscles well calculated for that purpose, so in man, who has a larger share of understanding than other animals, this great variety and multiplicity of foldings in the brain, was undoubtedly designed for some particular end. Besides, we observed all the apophyses, or productions of the nerves which come from the brain; so that to state all at once, the brain is visibly the principal of every thing that passes in the body; for the sense of smelling proceeds from the nostrils being pierced in order to have communication with the nerves; the sense of hearing is also produced by the like communication of the nerves with the ears; the tongue and the eyes receive also the productions of the nerves of the brain."

On reviewing the opinions of these eminent men, we must conclude that they had studied the anatomy of the brain with greater care than any of their predecessors, and had obtained a pretty general and accurate idea of its function and importance. We cannot therefore but admire the sagacity, that in an age so barbarous, and so prejudiced against anatomical inquiry, led to the generally correct results which distinguished their labours.

The records of the remaining Greek physicians do not appear to throw any new light on the anatomy or physiology of the brain. Nor do those appertaining to the Romans, until the time of Rufus of Ephesus, who lived under the emperor Trajan. He traced the nerves from their origin in the brain, and divided them into those of sensation and those of voluntary motion. He says,* "the upper part of the brain is called the varicose, the inferior and posterior the base; and the process arising from it the cerebellum. Two kinds of nerves arise from the brain, viz., the sensatory and the voluntary, by which sensation and voluntary motion are produced, and all the actions of the body are accomplished. Some of these nerves arise from the spinal marrow, and its investing membrane." Again, he says,† "The senses which proceed from the brain and spinal marrow are divided into the active, the sensatory, the voluntary, and the tensive." Rufus pointed out the decussation of the optic nerves at the infundibulum, distributed the nerves coming from the brain into seven pairs, first described the nervus palatinus, and discovered the par vagum, which he termed the sixth pair.

* De Part. Corp. Hum. lib. I, c. 23. † Op. Cit. c. 35.

Aretæus paid much attention to anatomy, but his physiological opinions were rather extraordinary. He maintained with Erasistratus, that the nerves were not only the organs of sensation, but likewise the source of all the action and motion of the limbs. Instead of ascribing the faculties to the brain, he attributed them to the stomach, which he conceived to preside over pleasure and pain, and to affect the mind through its consent with the soul. He is the first writer who has remarked the influence which the mind exerts over the health of the body, and the reaction of the body upon the mind; a fact, he observes, which we content ourselves with admiring, without hoping to be able to detect its cause. In his work *De Morbis Chronicis*, he gives the following account of paralysis, which would seem to indicate that he was not unacquainted with the distribution of the nerves into sensatory and motory:—"Apoplexy, paraplegia, and paralysis are all diseases of the same kind, for they are all a defect of motion or touch, or both; sometimes of mind, or of some other sense. If the sense of touch alone be deficient, (but this is of rare occurrence), the disease is more properly called insensibility. Sometimes the nerves proceeding from the brain suffer, which generally occasions insensibility, but not readily loss of motion; and yet if they are affected sympathetically with the parts which are moved, they may even undergo a certain loss of motion, for they have naturally a certain power of motion, and sometimes the nerves which pass from muscle to muscle have this power of motion, and impart it to the nerves which arise from the head; for they have the greater part of their motion from the other class, but they have a certain share themselves. The others rather suffer loss of motion; sometimes, however, though very seldom, they undergo also loss of sense."*

Galen divided the faculties of the human body into the natural, the vital, and the animal.† The brain he held to be the seat of the animal powers; that is to say, he considered it to be the organ from which sensation and motion are derived; and these he maintained were the powers by which animals were distinguished from vegetables. The natural faculty he placed in the liver—the vital in the heart. These three faculties produced the three sorts of actions, according to Galen, which are designated by the same

* De Morbis Chronicis, lib. 1, c. 7.

† De Facultatibus Naturalibus.

epithets, and which he divided into internal and external. The internal animal actions are imagination, judgment, and memory; the external are the five senses, and muscular motion, which he reckoned, as did also Hippocrates, to be one of the senses. The internal vital actions are violent passions, as anger, &c.; the external are motion, the pulsation of the arteries, and distribution of the spirits through them, diffusing life and heat. The internal natural actions are sanguification, the digestion of food, and the actions connected with it; the external are the distribution of the blood by the veins, for the purpose of nourishing, enlarging, and preserving the body. Besides these, which are general, Galen admitted of particular faculties, residing in each organ of the body, and directing its movements; and if he were asked what was the prime mover of all these faculties, he answered, with Hippocrates,—Nature. Galen decidedly taught that the nerves of the senses are distinct from those which impart the power of motion, and that the former derived their origin from the anterior part of the brain, or cerebrum, and the latter from the posterior, called by the Greeks *encephalis*—(under this term he comprehended the cerebellum, tuber annulare, and medulla oblongata of modern anatomists)—or, from its process, the spinal cord. He maintained that the nerves of the five senses are formed of matter too soft to be the vehicle of muscular motion, and too hard to be susceptible of fine sensibility.*

Oribasius, Ætius, Alexander, Paulus, and others, adopted the physiological views of Galen concerning the brain, and brought forth nothing new respecting it. Alexander describes phrenitis accurately, and confutes the notion that it is an affection of the diaphragm, and not of the brain. Paulus also wrote at great length on the diseases of this organ.

Theophilus† was the first to trace the olfactory nerves from their origin in the brain, to their expansion upon the membrane lining the nostrils, so as to form the organ of smell.

Serapion, Rhazes, Avicenna, and the other Arabian physicians followed the opinions of Galen.

Haly Abbas agreed with Aristotle respecting the brain, namely, that it is the coldest viscus, and antagonizes the heat of the heart;

* De Usu Partium, lib 8, 9. 10. De Placitis Hippocratis et Platonis, lib. 7; et Anatomicæ Administrationes.

† Wrote between the years 610 and 641.

for he says that those parts of the body which are vascular, and contain much blood, are naturally hot; whereas such as contain little blood, are comparatively cold. Of this latter class are the brain, nerves, and fat.*

Albucasis wrote a good chapter on operations on the head, particularly the manner of operating in dropsy of the brain, observing that water is effused not only on the surface, but into the ventricles of the brain, which he regarded as incurable, and a case in which no prudent surgeon would operate.

Notwithstanding the great encouragement the Arabians had from their princes, and advantages derived from the remains of the Alexandrian Library, little advance was made in the study of physiology, or even in anatomy. The fact is, that they were chiefly engaged in translating the works of the older writers, whose opinions they adopted.

William of Salicetum, born 1280, was the first after Galen, who made any original observations on the brain and nervous system. When speaking of wounds of the thorax, he makes some important remarks upon the nerves of the part, observing that those which proceed from the sixth or seventh pairs, derive their origin from the brain, and serve for the purposes of voluntary motion, while those arising from the cerebellum and spinal marrow, serve for the actual or vital functions, a circumstance which he illustrates by the symptoms of apoplexy. In these views, therefore, he somewhat approached the theory of Willis, who, four centuries after, pointed out the difference between the cerebrum and cerebellum, as consisting in the one presiding over the vital, or involuntary actions, the other over the animal or voluntary ones.

Guido de Chaulia, an English physician, who flourished in the year 1363, relates the case of a man who recovered after the removal of a considerable portion of the cerebrum, or anterior part of the brain, a circumstance the more worthy of remark, on account of its being perhaps the first case of the kind upon record in the annals of surgery,—for although Galen and others speak of injury of the brain, they are silent with respect to the removal of any portion.

Numerous anatomical works were now published, and among other subjects the brain received a considerable share of attention. Anatomists, however, were principally engaged in disputing

* Theor. lib. 1.

about the opinions of Galen, and the controversies which ensued (carried on by such men as Ingrassius, Vesalius, Fallopius, Eustachius, and others,) tended to increase the knowledge previously possessed.

Of all who entered into these disputes, perhaps Vesalius was the most eminent. He endeavoured to detract from the reputation of Galen, on whose opinion the medical world had relied for so many centuries. He calls in question his anatomical knowledge, affirming that Galen drew his descriptions from the bodies of apes, and other brute animals, and brought forward as discoveries things he imagined, and never saw. Yet in the account given by Vesalius of the nervous system, he has not been able to point out more than two or three errors of Galen, the greatest part of whose anatomy and physiology on this subject he is under the necessity of adopting. With Galen, he considers the brain as the seat of the rational soul, which acts on the sentient and moving parts by the animal spirit and nerves; and thinks with him also, that from the blood-vessels, in their winding course, the vital spirit is formed, from which with a portion of air insinuating itself into the brain, the animal spirit is first prepared. This is afterwards elaborated in the ventricles of the brain, whence a portion of it is carried into the ventricle of the cerebellum, and into the spinal marrow, and so to the nerves arising from it; the spirit passing from the other ventricles into those nerves which have their origin near to them, and by them to the organs of sense and voluntary motion. He admits with Galen that the nerves vary with respect to hardness and softness, the former being for the purposes of motion, the latter for sense.

This attack of Vesalius induced many anatomists to stand forth in the defence of Galen. Amongst others, Laurentius, who lived in the beginning of the seventeenth century, distinguished himself. He adopts the anatomy and doctrines of Galen, relative to the nervous system, and agrees with him also in respect to the nature, uses, and distribution of the nerves themselves. He says that the faculty of feeling and moving flows from the brain to the whole body of the nerves; but whether this faculty alone flows, or with it something corporeal, admits of dispute. He says that the nerves have no perceptible cavities, but that their substance is fistulous and spongy; yet he thinks it possible that the animal spirit, which is the most subtle of all things, may flow through cavities in nerves which we cannot discern. Laurentius does not

agree with Galen in his opinion that the nerves of sensation arise from the brain, and those of motion from the spinal marrow; nor does he admit universally that the nerves for motion are hard, and those for sensation soft. He offers some ingenious conjectures in explanation of the circumstance, that feeling sometimes remains when the power of motion is lost, and the contrary.*

A host of anatomists and physiologists now followed, all of whom more or less studied the brain, and in a greater or less degree added something to our knowledge of its functions. It would be tedious to describe the labours of each, (though, for the most part they implicitly believed in the doctrines promulgated by Galen,) I shall therefore only mention cursorily, those who were most distinguished for their discoveries and opinions.

John Dryander, in 1537, published a work, in which he pointed out the distinctions, unnoticed before his time, between the cortical and medullary portions of the brain. He also saw the olfactory nerves, which he miscalled the optic.

Volchu Coitu, discovered that the brain derived its motion from the arteries. He also ascertained that this organ was not essential to life, as some animals survived its removal.†

Varolius described the transverse portion of the brain, which has been denominated in honour of him, the pons varolii. He also discovered the glands of the choroid plexus, and was the first who divided the brain into three portions, by adding the medulla oblongata, previously to its issuing from the skull, and giving birth to nerves whose origin had been supposed to be in the brain.

Malpighi, by his microscopical investigations, discovered the glandular structure of the cortical substance of the brain; he seems also to have had some idea of the fibrous nature of the medullary portion, for he states that this part of the brain in fishes resembles somewhat the pipes of an organ,—that he had observed the same fibrous structure in the brain of sheep, oxen, and other animals, but that it was best seen in the posterior part of the medulla oblongata.‡

William Briggs found that the expanded filaments of the optic nerve lie in the most regular order, and that they continue to retain this order, when afterwards united in the nerve, and preserve it unbroken until they reach the brain.

* Laurentius, lib. iii. quest. 11.

† He published in 1566.

‡ Exercitatio Epistolica de Cerebri, 1664.

Vieussens wrote largely on the brain, and dissected the organ with extreme care. He was the first to trace the medullary fibres, and exhibit the connexion that existed between the crura of the cerebrum, and the corpora pyramidalia, by means of longitudinal fibres of white substance passing through the annular protuberance. He also pointed out that these fibres could be more readily traced after boiling the brain in oil.* In demonstrating, he first exposed the corpus callosum, from which he considered the fibres arose, and by slicing off the hemispheres, formed what has since been called from him the centrum ovale. He then exhibited the transparent partition, (or communication between the cerebellum and corpora quadrigemina) called after him the valvula vieussenii, and so proceeded to examine the fornix, &c.

In 1664, Willis published his Cerebri Anatome, followed in 1672 by a work entitled De Animâ Brutorum, &c., in which he considers the soul of brutes to be the same with the vital principle in man, corporeal in its nature, and perishing with the body. His reputation, however, principally depends upon his first book. In this he attributed a different action to the spinal cord, the cerebellum and the brain, and attempted to establish the cerebrum as the organ of voluntary motion, and the cerebellum that of involuntary motion. By the term cerebellum he also included the pons varolii, and medulla oblongata, and on these circulation, respiration, and digestion were dependent. He placed the vital property in the cerebellum, and the animal faculty in the cerebrum, imagination in the corpus callosum, perception in the corpora striata, and memory in the convolutions of the cerebrum. Willis, therefore, was the first who endeavoured to explain the phenomena of brain, by attributing to separate portions of its structure different functions.

Antonio Paccioni, a native of Rizzio, published, in 1721, his final disquisition on the supposed muscular nature and action of the dura mater. His opinions were maintained with considerable ingenuity, and the investigations to which the controversy led, contributed greatly to improve our acquaintance with the parts which were connected with the subject in dispute. During his dissections, he discovered the glands which bear his name.

The opinions of Haller, although of the utmost importance, it would be unnecessary to detail at length here. The example he

* Lib. i. c. 8 and 10.

held out of carefully abstaining from all opinions founded upon speculative grounds, and of deducing his general principles merely from experiment and observation, was of the utmost advantage. By these means he established his theory of irritability and sensibility, as specific properties attached to the two great systems of the animal frame, the muscular and the nervous, to which either separately or conjointly may be referred all the phenomena of the living body. He was opposed to the doctrine which places the various faculties of mind in different portions of the brain and cerebellum, and contrary to the opinion of Willis, concludes from numerous cases of the fatal effects of injuries, that sensation resides in the cerebrum, and volition in the cerebellum.

The opinions of Haller gave rise to much controversy, which assisted greatly in forwarding, among other subjects, the physiology of the brain. Whytt and Porterfield, particularly the former, opposed the Hallerian doctrine. He attributed vital motions to the operation of the sentient principle, which he supposed to be something distinct from the corporeal frame, at the same time that it was necessarily attached to it, and under the influence of physical causes.

The fibrous structure of the brain having been examined by Malpighi and Vieussens, was successfully prosecuted by Professor Reil, who in 1795, published a paper on this subject in Gren's Journal, followed by others, in which he gave a minute account of the fibrous structure of the cerebellum—traced the fibres from the pyramidal bodies through the pons varolii to the crura cerebri, and from thence through the corpora striata to the convolutions; he investigated the fibres of the corpus callosum, and anterior commissure, and traced them into the hemispheres. He also described accurately the structure of the convolutions, and remarks if one were to fix upon a point in the nervous system, such as the medulla oblongata, this system might be regarded as radiating from this point to the extremities of the nerves on the one hand, and to the extremities of the fibres of the cerebrum and cerebellum on the other; or that all these fibres might be considered as converging from their extremities towards the medulla oblongata.

The opinions of Bichat, owing to their ingenuity, and the eloquence with which they were maintained, excited the greatest sensation among physiologists. In 1805 he published his work, "Recherches Physiologiques sur la vie et la mort," in which he divided the nerves into two distinct systems, animal and organic,

the one having for its centre the brain, and consisting of those nerves which received impressions, or were subservient to volition; the other had many centres, existing in the ganglia, each of which possessed a distinct source of nervous influence, although an intercommunication took place between them by means of nerves. The first, according to him, presided over sensation, voluntary motion, and intellectual power; the second governed those operations of the animal economy over which the mind had no control, together with the passions.

As we approach our own times, in which so much has been written on the structure and functions of the brain, it becomes obviously impossible to give even an outline of the various works produced. The anatomists of England, France, Germany, and Italy have with the greatest talent and diligence endeavoured to discover those laws which govern the operations of brain, and the connexion which exists between mind and matter. Great progress has latterly been made in the pursuit, and we may reasonably hope that our knowledge of the functions which the nervous system performs will at no very distant period equal our acquaintance with the physiology of other parts of the animal economy. The recent discoveries will be noticed in the following pages; and being now acquainted with the opinions of authors up to the time of Bichat, we shall be better prepared to enter on their consideration, and appreciate the important results to which they have led.

PART I.

ON THE FUNCTIONS OF THE BRAIN.

The brain, cerebellum, and spinal marrow, in a purely scientific point of view, cannot but be considered as one organ. The separation, however, although arbitrary, like the divisions in every branch of science, tends to facilitate the more minute study of each portion, and favours the acquisition of knowledge, when directed to it as a whole. In the following pages, when speaking of the brain, I shall therefore use it in the common acceptation of the term, as the contents of the cranium, divided into cerebrum, cerebellum, pons varolii, and medulla oblongata; but from the intimate connexion that exists between it and the spinal cord, the latter will necessarily receive some share of consideration.

The functions that physiology and pathology warrant us in ascribing to the brain, are those of sensation, motion, and intellectual power. The two former it possesses in common with the spinal marrow, the last is peculiar to itself.

That sensation and motion are somewhat dependent on the brain, is proved by the destruction of these functions on the removal by the experimentalist of certain portions of its substance—by the sudden effects of injury, or the more slow progress of disease. On the other hand, in some of the lower animals, sensation and motion appear to be carried on equally

well without a brain, amphibia living for months after decapitation, and some of the warm-blooded animals, such as birds, continue to live and move some time after the separation of the head from the body. The brain has also suffered very extensive lesions, and been diseased to an enormous extent, without in any way affecting either of these functions. Facts confirmative of this opinion are so numerous, that we cannot hesitate in stating, that the brain is not the only source of sensation and motion.

That the manifestations of mind are attributable to the brain, is now generally acknowledged. With the metaphysical inquiry into this subject we have nothing to do, and shall leave the question of the dependence or non-dependence of mind on matter, to the speculations of theologians. But physiologically and pathologically considered, we cannot doubt that mind is inseparably connected with brain, and all our observations of the animal economy, in its healthy or morbid condition, tend to confirm this truth. In the infant, (as argued by Lawrence), like the body, it is weak and without vigour. As the brain acquires firmness, the intellect proportionally increases and advances in power in an equal ratio with the bodily strength, until in the adult it has assumed all the powers of which it is capable. As the body and general organization decline in strength, the mental powers diminish, until the one being decrepid, the other becomes fatuous. Original malformation of the brain is always accompanied by defective mind, whereas an enlarged healthy development of that organ is followed by an increase of the intellectual powers. Besides, on removing the cerebral lobes in animals, physiologists have uniformly found them become dull and stupid, observing that all control over their motions was lost. Pathology shews us that the various manifestations of mind, such as judgment, memory, &c. are often impaired when the brain is diseased either wholly or in part; that when the organ is compressed either by external or internal means, consciousness is destroyed, and on the removal of the compressing cause is again restored.

The labours of Tiedemann, besides establishing a general law of nervous development, have shewn that the appearance of the higher faculties and instincts in animals keeps pace with the development of brain. The zoophytes being destitute of nerves, possess no actions attributable to instinct or volition; and on examining the brains, in the different tribes of fishes, reptiles, birds, and mammalia, it has been proved that the brain receives various additions, according to the more perfect organization of the animal, and that these additions are accompanied by a more perfect state of the functions it performs.

These circumstances, therefore, fully warrant us in ascribing the functions of sensation, motion, and mental power to the brain. We shall now proceed to consider in detail what facts we possess in connexion with this subject from physiological and pathological researches.

SECTION I.

OF SENSATION AND MOTION.

Physiological Results.

Hitherto no satisfactory explanation has been given of the means by which sensation and motion are produced. That through the intervention of nerves the one is conveyed from the surface of the body to the brain, and that volition proceeds from the brain to the surface, the simple experiment of dividing a nerve sufficiently proves to us. Sir Isaac Newton imagined that this influence, whatever it be, was conveyed by oscillations; yet Haller, after the most careful examination with a magnifying glass, of a nerve, which at the time was throwing a muscle into violent contractions, could not observe the least movement in the nerve itself. Darwin thought that nerves contracted; but if they did so, they would be observed elongating and shortening their fibres; yet this has never been seen. Dr. W. Philip is of opinion, that the nervous and galvanic power are the same, and performed several experiments, with a view of proving this. Among

others he placed a shilling on the stomach of a rabbit, cut across the eighth pair of nerves, and bound some tin foil round their extremities, connecting the shilling with one pole, and the foil with another of the galvanic battery in action. Under these circumstances, although the influence of the brain was removed, the stomach performed its usual functions. Other experiments of a like nature tended to confirm Dr. Philip's belief. But the experiments of Sir B. Brodie and Magendie shew, that division of the eighth pair does not materially affect the function of the stomach, if made in such a manner as not to prevent or impede respiration ; and although some of Brachet's experiments are opposed to this conclusion, most physiologists have regarded these with considerable distrust. Besides, as advanced by Dr. Bostock, " before the electric hypothesis can be established, it will be requisite to prove that every function of the nervous system may be performed by electricity," an objection alone sufficient to refute it.

The seat of sensation had always demanded a large share of the attention of physiologists. Almost every portion of the brain has had this function ascribed to it. Descartes placed the seat of sensation in the pineal gland, which he considered also as the centre of mind ; Le Cas in the pia mater; Willis in the corpora striata ; Digby in the septum lucidum ; Sœmmering in the water of the ventricles ; La Peyronie in the corpus callosum. Haller states that it is in neither of these, but in the medulla of the cerebrum ; while Richerand imagines that it resides in the annular protuberance ; and Parfour Petit, Foville, and others, in the cerebellum.

Motion, in like manner, has been ascribed to different parts of the brain. By Willis, it was located in the cerebrum ; by Haller, Rolando, and others, in the cerebellum ; while Magendie, and many experimental physiologists, consider the corpora striata, and quadrigemina, as well as the cerebellum, to be connected with this function.

M. le Gallois pointed out* that sensation and motion were

* Expériences sur le Principe de la Vie.

more dependent on the spinal marrow than was generally supposed. He observed that, when a nerve was divided, all sensibility and power of motion ceased in the parts below the division, and concluded that these properties were derived from whence the nerves originated; and that as the nerves sprang from the brain, or spinal marrow, it is in these that the seat of sensation and motion should be placed. He found that in young animals he could preserve life for several hours after decapitation by pulmonary insufflation, during which time they possessed sensation and motion, which he considered more immediately depended on that portion of the medulla oblongata, giving origin to the eighth pair of nerves. If we open, he says, and cut away by slices the whole of the brain and cerebellum, and even some part of the medulla oblongata, the animal will continue to respire; but if the origin of the eighth pair be included in the section, respiration suddenly ceases. From numerous experiments he concludes that the principle of sensation and motion, as far as relates to the trunk, resides in the spinal marrow. These consisted in destroying the spinal marrow by irons, making various sections of it, &c. From these experiments he wished to shew not only that the life of the trunk depends upon the spinal marrow, but that the life of each portion depends only on that part from which it receives nerves; and, among others, adduces the following experiment as confirmatory of this opinion. He opened the breast and abdomen of a rabbit, tore out the lungs, the diaphragm, the intestines, and all the viscera of these two cavities, then cut off the head, leaving only the skeleton, the muscles, and the spinal marrow, when he found that life continued, and sensation and motion were present; but when he destroyed a portion of the spinal marrow, those parts supplied by this portion only were struck with death; and, on destroying the whole, death took place universally. He, therefore, concludes that the life of the trunk resides in none of the viscera of the breast or abdomen, nor in the brain, (although they are all necessary to the animal economy,) but in the spinal marrow. He, however, still considered the brain to perform an important part in

directing motion: thus, on moving the arm, the principle of this motion depends on the spinal marrow, but it is the brain which wills this motion and directs it to the object. He observed, also, that some portions of the brain might be destroyed or injured without affecting sensation or motion, and considered that the seat of this principle was not diffused over the whole cerebral mass, but limited to a certain part named *sensorium commune*. When cold-blooded animals have been decapitated at the first vertebra they will still live; but although they move their body and limbs with as much force as is necessary to transport them from place to place, they remain in the same situation; and, on examining the motions they make, it is observed that they are irregular and apparently undirected to any object. He says, that in those cases where reptiles possess the power of moving after decapitation, it arises from the incomplete performance of this operation, and that the posterior part of the brain remains in union with the body.*

Dr. W. Philip, who has repeated Le Gallois' experiments, and acknowledges their correctness, deduces from them a very different conclusion. He says that motion is entirely independent of the brain and spinal marrow, and asks,† "Why, if the power of the heart depends on the spinal marrow, as it appears to do, from the experiments of Le Gallois, have fœtuses been born alive, where no spinal marrow had ever existed? Why does it continue to perform its usual motions after it is removed from the body? Why, if the various organs of involuntary motion bear the same relation to the nervous system, is the function of the heart uninfluenced by decapitation, and that of the stomach immediately impaired by dividing or throwing a ligature round the eighth pair of nerves? Why does respiration cease on the destruction of a certain part of the medulla oblongata, since the nerves of the muscles employed in respiration arise from the spinal marrow, which M. Le Gallois has proved to be capable of exciting the muscles indepen-

* This observation of Le Gallois' assimilates with the experiments of Flourens, Rolando, and others.

† On the Vital Functions, pp. 52, 53.

dently of the brain ?" He considers that Le Gallois' doctrine cannot reconcile these objections, and is therefore erroneous. Although Dr. Philip's experiments have led him to conclude that motion is not dependent on nervous matter, they, at the same time, shew that it is capable of influencing it: an apparent contradiction which experiment proves to be the case, and which is as yet unexplained.

Dr. Philip has demonstrated that an influence is exerted by the brain over the motific function, from the effects which followed the *application* of different stimuli to this organ. Some experiments, performed by Professor Mayer* on the lower animals, proves still further the existence of this influence from the result obtained by *abstracting* a portion of the stimulus usually conveyed to the brain. He, in several instances, tied the vessels which supply the brain with blood, and found that after placing a ligature on one carotid artery, the circulation of the brain was not materially impeded, but that when both carotids were tied great derangement in the functions of the brain followed. He perceived giddiness, loss of sensation, motion, and consciousness, with indifference to the usual instinctive stimuli ensue, together with a feeble respiration and action of the heart, followed by death. Although, from experiments performed by other physiologists, these effects have not been found always to result, we know that, after operations on the human subject, even when only one carotid has been tied, some of these effects occasionally follow. Some experiments by Sir Astley Cooper shew the same result; and it is curious how interrupting the blood, flowing to the brain, should, in some cases, produce such marked effects and not in others. An ingenious explanation of this has been offered by Dr. Knox.† He has often found, on examining the brain, that the communicating arteries of Willis are exceedingly small and sometimes impervious. In the former case the free communication of blood between the carotid and vertebral arteries would be much impeded, and in

* Edinb. Med. and Surg. Journ. vol. xliii. p. 407.

† Anatomical Lectures, 1837.

the latter altogether prevented. Hence the brain would be imperfectly supplied with blood, and the ill effects described, result.

Loss of blood is now well known to produce the same effects on the brain's functions as an excess.* The cause of this will be explained in a subsequent part of this essay; in the mean time these various facts point out more clearly the great influence which the brain possesses over sensation and motion.

Flourens, in his work on the nervous system, attempts to prove that the cerebral lobes are the seat of sensation and volition; that the nerves, spinal cord, medulla oblongata, and corpora quadrigemina, are alone the seat of those impressions which give rise to muscular contractions, so as to produce motion of the joints; and that the cerebellum regulates these motions so as to produce the actions of running, walking, standing, flying, &c. He found, that when the cerebral lobes were removed in an animal, it at once loses the senses of sight and hearing, but if the cerebellum only be removed, and the brain proper remain entire, these senses are unimpaired. If one hemisphere only of the cerebrum is removed, the sight of the opposite side is alone lost. He also observed, that the loss of the cerebral lobes was followed by a kind of lethargy, or deep sleep; and it is this fact which induces him to think, that besides being the seat of sensation, the cerebral lobes are the seat of volition. When both hemispheres of the cerebrum were removed in a pigeon, without injuring the corpora quadrigemina, or cerebellum, the animal was immediately seized with more or less feebleness, which effect, however, gradually diminished, till it soon became evident that motion was nowhere materially weakened. But the senses of seeing and hearing, as above mentioned, were extinguished, and a state of stupor was induced, resembling profound sleep. The animal remained calm, and as if abstracted, did not move of its own accord; and when it en-

* See Dr. M. Hall, On Bloodletting.

countered an obstacle, struck it again and again, without trying to avoid it. Yet it preserved its equilibrium, struggled if held, resisted every effort made to open its beak, swallowed water dropped into it, walked about when pushed, and flew when thrown into the air; the slightest irritation evidently annoyed it.* These phenomena, although they by no means show that sensation and motion were wholly lost, yet prove that they are considerably impaired. The French commissioners who reported on this subject say—"We should be content with holding that the cerebral lobes are the sole receptacle, where impressions on the senses of sight and hearing become perceptible to the animal. If we were to add anything to this concession, we should say that they were also the part where all sensations whatever take a distinct form, and leave durable traces and recollections; in a word, that they are the seat of memory, by which property they supply the animal with the materials of judgment."†

Rolando of Turin performed numerous experiments before those of Flourens were made known, which led him to the same conclusion concerning the seat of sensation. He observed in cocks, crows, kids, lambs, and guinea-pigs, that after the cerebral lobes had been removed, those animals stood motionless for hours together, but that they preserved their equilibrium, sought for support, and could be made to walk when struck violently. It is evident that sensation and motion, however impaired, were not destroyed in these experiments.

Magendie found that young rabbits, jackdaws, and magpies ran about and jumped vigorously and spontaneously after removing all the brain anterior to the optic thalami.‡ He accounts for the different result which he arrived at, from that of the two former physiologists, by the care he took to prevent extravasation and compression, and which he thinks was not sufficiently guarded against by them.

* Archives General, ii. p. 352.

† Journ. de Physiol. vol. ii. p. 381.

‡ Ibid. vol. iii. p. 155.

We may then fairly conclude, that as neither Flourens nor Rolando have shown that sensation and motion are totally destroyed on the removal of the cerebral hemisphere, whilst in several animals sufficient care being taken to prevent extravasation, little effect is produced; these functions cannot be said to belong exclusively to the hemispheres of the brain.

The experiments from which Flourens deduces that the cerebellum is the regulator of motion, are numerous, have been confirmed, and demand our utmost attention. On cutting away a slice from the cerebellum of an animal, the injury is at once followed by great weakness, but in a short time the animal regains its strength, and the senses are then found to be entire. It shrinks from the slightest threat or violence offered to it, and the motions of the limbs are generally vigorous and frequent, but its movements are exceedingly irregular, and, as it were, embarrass each other; and though volition is evidently exerted, no corresponding act succeeds; it strives to escape when irritated, yet it can neither fly, run, leap, or walk; and when the whole cerebellum is removed, it cannot even stand. If that organ be removed gradually in successive thin slices, the progressive circumscription of the locomotive actions is very remarkable. On removing only the first layers of the cerebellum in the pigeon, the sole effect produced is some weakness, and a kind of hesitation in its gait. When the sections have reached the middle layers, it staggers much, and assists itself in walking with its wings; yet it sees and hears perfectly, seems cheerful, and does not express pain. The sections being continued farther, it is no longer able to preserve its equilibrium without the assistance of its wings and tail; its attempts to fly or walk resemble the fruitless efforts of a nestling, and the slightest touch tumbles it over. At last when the whole cerebellum is removed, it cannot support itself even with the aid of its wings and tail; it makes violent efforts to rise, but only rolls up and down; then, fatigued with struggling, it remains for a few seconds at rest on its back or belly, and then again commences in vain, struggles to rise and walk. Yet all the while its sight

and hearing are perfect, the slightest noise, threat, or stimulus at once renews its contortions. In these struggles there is not the slightest appearance of convulsions. The same effects where observed by Flourens in the guinea-pig. When the last layers of the cerebellum were removed, it lost the power of walking or standing, lay down on its belly, moved its legs as if running, and made vain efforts to rise. Such are the facts from which he has drawn the inference that the cerebellum is the regulator of all locomotive actions.

Rolando maintains that the cerebellum is the organ on which motion entirely depends. After removing the cerebellum from many mammalia and birds, he found that motion diminished in proportion to the quantity of matter removed. The experiments of Magendie, however, are hostile to this view. He says, that after having entirely removed the cerebellum in animals, they notwithstanding performed very regular movements. He has seen hedgehogs and guinea-pigs deprived both of brain and cerebellum, rub their noses with their paws in front, when a cruet of vinegar was placed under their nostrils. These movements, however, may be instinctive. Le Gallois mentions that, after decapitation, the trunk seems often to be influenced by a sort of instinct or will. He found that guinea-pigs, and kittens, on recovering from the stupor produced by decapitation, appeared to feel pain from the wound in the neck, as seems evident by the alternate motion of their hind feet towards that part. Sir G. Blane* divided the spinal marrow of a kitten by cutting it across the neck. The hind paws being then irritated by pricking them, and by touching them with a hot wire, the muscles belonging to the posterior extremities were thrown into contraction, so as to produce the effect of shrinking from the injury. In repeating the experiment, he found, that when the spinal marrow was cut through between the lumbar vertebræ and the os sacrum, the posterior extremities lost their irritability, but the tail retained it. It appears, therefore, that some motions take place independently of the brain, as is still further evinced by the birth of acephalous

* Lecture on Muscular Motion, read to the Royal Society, 1788.

fœtuses which have lived for some short period. Nay, fœtuses have exhibited motion when born without a brain or spinal marrow.

Dr. M. Hall* has lately endeavoured to prove that many of these motions described by Le Gallois, and by some termed instinctive, are independent of sensation and volition; and seeks to establish a new system of nerves which he calls excito motory. Having divided the spinal marrow in a frog below the occiput, on pinching the toe, the extremity is retracted. The same takes place in animals after decapitation, or when they have been stunned by a blow on the head. These experiments, similar to those of Le Gallois and Sir G. Blane, only confirm the views of the former, who considered that sensation and motion reside in the spinal cord, and that these functions may be exercised independently of the brain.

That sensation and motion derive their origin from two distinct sources, is fully proved by the experiments of Sir C. Bell. He has shown the impossibility of supposing that the nerves receive all their influence from the brain, and by the most conclusive experiments has demonstrated that sensation and motion may be traced to the spinal marrow, which he has proved to consist of a double cord—the anterior originating motion, the posterior sensibility. He has shown that the spinal nerves may be separated into fasiculi, some of which arise from the anterior, others from the posterior part of the medulla spinalis, and considers that each filament has its own particular endowment, which it retains through its whole course. Thus, the filament arising from the sensitive part of the cord, bestows the property of sensibility on every part where it is distributed, while that connected with the motific portion communicates the influence of the will to the muscle, and causes it to act. Thus, "a circle is established between the sensorium and the muscle; one filament or simple nerve carries the influence of the will towards the muscle, which nerve has no power to convey an impression backwards to the brain, and that another nerve connects the muscle with the brain, and

* On the Nervous System.

acting as a sentient nerve conveys the impression of the condition of the muscle to the mind, but has no operation in a direction outward from the brain towards the muscle, and does not therefore excite the muscle, however irritated."*

The experiments on which this opinion is founded, are too well known to require description. They have been confirmed by Magendie, and a host of physiologists, and are universally acknowledged as being conclusive.

Sir C. Bell has also demonstrated that there are two kinds of sensibility, one relating to the condition of our bodily frame, the other intimating to us the nature of the matter which surrounds us, and the properties it possesses. The former has been called common, the latter special sensibility. These are affected by different stimuli ; the impressions felt by the special organs of sight, hearing, smelling, and taste, are unheeded by the more common sense of touch which resides in the integuments ; while injuries and lacerations of the nervous substance imparting peculiar sensibility, are not followed by the pain they cause in the skin, where general sensibility is situated.

It is the opinion of Magendie and Desmoulins that all special sensibility is dependent on the trigeminal nerves, and they deduce this conclusion from the following arguments, viz. When the fifth pair is divided, all the special senses are destroyed, or at least enfeebled ; when the special nerves alone are divided, the animal still retains in part the capability of receiving odours, taste, sound, and light ; but if the fifth pair is divided at the same time, these sensations are utterly and entirely annihilated. The mole has no optic nerve, but instead of it there is a twig of the fifth pair ; in fishes there is no auditory nerve ; in the cetacea no olfactory nerve ; and yet these animals have in all probability a certain degree of the corresponding sensations. Certain of the special sensations may be produced in other ways than the contact or impression of the ordinary stimuli giving rise to them ; thus, for example, sound may be heard, although the external ear be plug-

* On the Nervous Circle.

ged up, if a watch be applied to the head, or put between the teeth. All these arguments are liable to powerful objections, some of them are fallacious. If the sense of vision depended on the fifth pair, it would immediately cease on dividing the nerve; this is not the case; no immediate effect is produced, but a gradual action commences, which terminates in the disorganization of the cornea and conjunctiva, producing also muddiness of the humours, and it is from these secondary causes that vision is rendered impossible. That the mole has no optic nerve, is denied by Carus and Geoffroy St. Hillaire. I have, however, carefully dissected the brain in six moles, and examined the base of the brain, and the nerves coming from it, with powerful glasses, without being able to detect any appearance of the optic nerve. It is unlikely, therefore, that the mole possesses the power of viewing objects distinctly; it may indeed be enabled to distinguish light from darkness, as the fifth pair may possibly bestow such sensibility on the parts as to make it sensible of light; and for this merely it does not appear necessary that there should be an optic nerve. As regards the absence of olfactory nerves in the whale tribe, it is not universal. I saw the brain of a young whale (Minor Rorqual) removed from the cranium, by Dr. Knox, which had the olfactory nerves fully developed; and that gentleman having shewn that some of this class of animals possess olfactory nerves, while others do not, it is generally believed that the former only are endowed with the power of smell. Sound can certainly be heard when the external ears are plugged up, in the same manner as those animals are conscious of sound who have no external ear; but it is by the general law which regulates the conveyance of sonorous vibrations. No doubt the trigeminal nerve has a great influence on the exercise of the special senses; but this is to be ascribed either to the loss of that common sensibility which is its guard against irritations, and which appears indispensable to the proper secretion of mucus, lining the external mucous membranes. Thus, after division of the fifth, these become inflamed, cease to secrete the fluid which keeps them moist in a state of health,

and a condition is occasioned which renders a proper performance of their functions impossible.

It was noticed by Fodera,* that the removal of part of the cerebellum was followed in all cases, either by motion *backwards*, or by that portion of the body which precedes retrograde movement. Magendie found, that on removing the corpora striata in mammalia, the animal darts forward with great rapidity; if it stops, it preserves its attitude of escape. On injuring the cerebellum, he observed that the animal attempted to move backwards. Hence he imagined there were two powers in equilibrium, one leading forwards, the other backwards; and that when either of these are injured, the force of the other preponderates, and produces an irresistible movement one way or the other, according to circumstances. On dividing one of the peduncles of the cerebellum, the animal begins to roll laterally on the same side as the divided peduncle, with great force, and sometimes with so much rapidity, that the animal makes more than sixty revolutions in a minute. The nearer the section is to their origin from the pons varolii, the more rapid is the motion. He has seen this movement continue for eight days, without stopping for a single instant. On dividing the cerebellum into two lateral bodies, perfectly equal, the animal was alternately impelled to the right and to the left, without preserving any fixed situation. Besides the powers, then, which impel an animal forwards or backwards, there appear to be others which govern lateral and rotatory motions of the body. Mayo† thinks the simplest and most rational explanation of these phenomena is, that these various injuries produce in the animal a sensation analogous to vertigo, and that the animal conceives itself to be hurried in various directions opposed to those which take place, and which are produced by the efforts he makes to repel this imaginary force.

That these movements are occasioned only by injuring par-

* Journal de Physique, July 1823.

† Mayo's Physiology.

ticular parts of the brain, is shewn not to be the case, by several experiments of M. Flourens, who found almost the same effects follow lesion of the semicircular canals in birds.* Division of the horizontal canals on each side occasioned a rapid horizontal movement of the head from left to right and back again, and loss of the power of maintaining an equilibrium, except when standing, or perfectly motionless. There was also the same singular rotation of the animal round its own axis, which follows injury of the crura cerebelli. Section of the inferior vertical canal on both sides produced violent vertical movements of the head, with loss of equilibrium in walking or flying. There was in this case no rotation of the body upon itself, but the bird fell backwards, and remained lying on its back. When the superior vertical canals were divided, the same phenomena were observed as in section of the inferior, except that the bird fell forward on its head, instead of backwards. All the canals, both vertical and horizontal, having been divided in another pigeon, violent irregular motions in all directions ensued. When, however, the bony canals were so cautiously divided as to leave their internal membranous investment uninjured, these motions were not produced. This would lead to the supposition that it is in the expansion of the acoustic nerve that the cause of these phenomena must reside; but why lesion of a nerve supposed to minister exclusively to the sense of hearing should produce such derangement in motion, has not been attempted to be explained.

Bellingeri† attributes to the hemispheres the power of producing the motions of flexion, and to the cerebellum that of causing extension. He points out, from the experiments of Magendie, Flourens, Serres, and others, that removal or injury of the anterior lobes of the brain is followed by flexion of the abdominal extremities, while division of the posterior lobes is followed by flexion of the thoracic extremities. In

* Memoires de l'Academie des Sciences, vol. ix. p. 454.

† Edinb. Med. and Surg. Journ. vol. xliii. p. 160.

support of the latter proposition he adduces the comparative weight of the brain and cerebellum at different ages. He concludes from the authority of Chaussier, that the weight of the cerebellum is the eighth or ninth part of the brain, and that in the infant the difference is greater. He observes, that the motions of extension are more predominant in the adult than in the infant, in whom the motions of flexion are most apparent, and which is incapable of sustaining the head and trunk, and supporting itself erect, positions easily maintained by the adult, from the greater development of the hemispheres in the fœtus, the flexed position of the body, and in infancy the predominant action of the flexor muscles. This opinion he considers farther illustrated, by having observed in those children who had the occipital region much developed, stand and walk earlier than those in whom it is depressed, or little elevated.* He considers also that the experiments of physiologists agree with this doctrine. The motions of retrogression observed by Magendie on injuring the cerebellum are to be explained by the spasmodic actions thus induced in the exterior muscles, which compel the animal to move backwards. Fodera has described the position of a guinea-pig, after removing the superior part of the cerebellum, as being that of the head thrown back, the hind legs forcibly separated, the fore legs straight and rigid, &c. and Bouillaud has observed injuries of the cerebellum followed by opisthotonos.

* The observations of Sir W. Hamilton (Monro's Anatomy of the Brain) agree in this respect with those of Bellingeri. He mentions that the young of those animals, (as the chicken of the common fowl, partridge, pheasant, &c.) who have from the first the full power of voluntary motion, and depend on their own exertions for subsistence, have the cerebellum as large as the adult; and in the calf, kid, lamb, and probably in the colt, the cerebellum at birth is very little less than in the adult. Whereas in those birds that have not at first the full power of voluntary motion, but which grow rapidly, the cerebellum does not arrive so quickly to its proper size; and in the young of quadrupeds that for some time depend on the milk of the mother for support, and which have at first feeble powers of regulated motion, the proportion of the cerebellum to the brain proper is very small; and by the aid of the full period of lactation, it reaches the full proportion of the adult. This is seen in the young rabbit, kitten, whelp, &c.

The latter physiologist has made numerous experiments, the results of which are, on the whole, similar to those of Flourens, Rolando, Magendie, &c.* He however concludes from them, that the regulating power of the cerebellum is confined to the muscles of locomotion only, and has no influence whatever over voluntary movements. He says, that the experiments of all physiologists shew that injuries of the cerebellum produce only disorder and confusion of those motions concerned in station and locomotion.

The same facts have received another explanation from M. Foville. He considers the cerebellum as the seat of sensation, and argues, that as it is by means of this function that we regulate muscular motion, (in proof of which he cites many cases of anisthœsia,) so when it is destroyed, the faculty of perceiving the movements being lost, we cannot answer for their precision or duration.

It will be seen, therefore, that great confusion is thrown on this subject by the difference existing among physiologists themselves. Farther particulars, all however of the same nature as those already quoted, may be obtained from the writings of Hertwig, Desmoulins, Shaw, Foderé, Serres, &c.; it is unnecessary to enter on their consideration here.

Having described the facts which have been derived from various experiments, we shall now inquire how much pathology has contributed to our knowledge of the functions of sensation and motion.

Pathological Results.

The pathological facts which bear upon this subject are both numerous and important, and are much opposed to the hypotheses, which experiments on the lower animals have engendered. All pathologists agree in considering it a matter of extreme difficulty to reconcile, with any degree of certainty, the morbid appearances found in the brain with the symp-

* Recherches Cliniques et Experimentales, &c.

toms previously observed. We cannot read any account of the diseases of this organ without being struck with the violent symptoms, which in some instances occur with trifling lesion of its substance, while on the contrary it is common to observe morbid destruction of the encephalon or its membranes to a great extent, where unimportant illness had existed, or where it had not even been suspected.* It is not then from a few cases that we are entitled to draw any deduction concerning the functions of any part of the cerebral mass, for such are the contradictory effects often obtained from apparently the same cause, that by judiciously selecting a few well marked instances, great plausibility may be thrown on various theories, however dissimilar. It must be evident that such a mode of proceeding cannot tend to the advancement of science, but rather produces from limited facts a confidence in opinions, which are often opposed to extensive inductions, or, at the most, owe their reputation to the ingenuity, rather than the candour, of their authors.

The diseases of the brain, which more particularly confirm or nullify results obtained by experiment, are those in which some organic lesion has been discovered, and it is to these we shall more particularly confine our observations. It must not, however, be forgotten, that circumstances independent of these affect the functions of the brain in a manner not less certain, and with a violence equally destructive. Thus sensation and motion have been powerfully increased or diminished, when, on dissection after death, the membranes only have been found diseased; and these have often presented the same morbid appearances in the dead body, subsequent to the presentation of the most varied symptoms during life.

Irregularities in the circulation of the brain have also produced every kind of derangement to which either sensation or motion is liable; for this organ is not only influenced by the general quantity and quality of the blood, as are the other viscera, but is peculiarly affected by the unyielding nature of

* See remarkable case by Mr. Earle.—Medical and Physical Journal, vol. xxiii., p. 89.

the parts which surround it. Thus it is very probable that a healthy state of the brain depends in no small degree on a just balance of the circulation in the arterial and venous vessels, more particularly as we see all those circumstances which tend to disturb it produce derangement of its functions; among these may be enumerated pressure, extravasation of fluids, mental emotions, external applications of heat, use of alcohol, &c.

In cases of insanity, we often observe that sensation and motion are not excited by their ordinary stimuli, or, on the other hand, these are morbidly irritable. Thus lunatics have had their fingers, toes, and even extremities mortified from the effects of frost, without having been aware of the circumstance; and one, during a paroxysm, having thrust his foot into the fire, allowed it to be burnt away without exhibiting the slightest pain. In some cases, the sensibility of the cutaneous surface has been rendered so acute, as to produce more than ordinary pain from the receipt of the slightest wound, or the application of an external stimulus. Dr. Falconer* mentions a singular case of this kind—that of a gentleman, who, having suffered from paralysis, experienced a sensation of intense heat on feeling any cold body, and imagined his shoes were getting cold, when in reality they were growing warm from animal heat. The senses of sight, hearing, smell, and taste may in such cases give rise to perceptions unusual to those generally produced:—For instance, obscurity of vision, and flashes of light before the eyes; imaginary sounds, obtuseness or great activity of hearing; smelling more or less depraved; and the taste so much so, that raw potatoes, candles, and even some disgusting substances, are devoured with the greatest avidity. Among the disturbances of motion caused by insanity, may be remarked the increased strength which lunatics often possess during the paroxysms, the immobility with which they sometimes appear to be affected, continuing in the same position often for days together; and with others, on the contrary, the restlessness and great activity that singularly characterizes their movements.

* Mem. of the Medical Society, London, vol. ii.

The morbid appearances met with in the brain are numerous; most of them, however, are to be considered as the result of inflammation, such as adhesions, effusions into the cavities, congestions, abscesses, hæmorrhages, discolorations, and some say softening, but that this is always the case is denied by others. Besides the disorganizations arising from inflammation, there are others, such as different kinds of tumours, tubercles, cancer, ossifications, indurations of the cerebral substance, depositions of albuminous matter, hypertrophy, and hydatids. Notwithstanding the contrary nature of these diseases, the symptoms found in connexion with them are very similar, and are by no means of such a nature as to allow any distinction to be drawn between one or the other. Many are common to the whole, such as headach, delirium, coma, &c. Observation also tells us that the same morbid appearance in different cases produces the most varied symptoms, while, on the other hand, the most dissimilar symptoms have originated from the same apparent cause. Neither does the situation in which the disorganization has taken place, point out any data which may lead us to a knowledge of the seat or nature of the mischief, many morbid alterations of the same kind having taken place in different portions of the brain, that previously presented the same indications of disease.

The loss of sensation and motion may be either general or partial, complete or incomplete. One may be injured without the other, or they may be simultaneously destroyed. Some diseases have been found to affect one function more than the other. Thus loss of sensation has been more constant after cerebral hæmorrhage than that of motion; and the contrary has been observed as the result of ramollissement. The accurate researches of Foville have shown, that when sensation and motion are permanently affected in lunatics, the medullary portion of the brain is invariably diseased. In chronic cases he describes it as being sometimes of a splendid white and much indurated; at others, the hardened medullary substance has a yellow tinge, or a grey leaden colour.

We generally find that diseases on one side of the brain produce paralysis on the opposite side of the body; an effect which pathologists attribute to the decussation of the pyramids of the medulla oblongata. It sometimes, however, occurs on the same side; but as the hemispheres of the brain are connected by two sets of filaments, by one to the opposite, and by the other to the same side; in these cases the latter is supposed to convey the morbid influence.

Many remarkable cases have been published where sensation has been impaired without the other functions of the brain being altered. Mr. Liston* removed the metatarsal bone of the little toe from a gentleman; which operation, though generally causing much pain, in him produced no suffering. The sentient power was nearly, if not altogether lost, while that of motion was so entire as to enable him to use his hands in carving his food, in writing, holding the reins on horseback, &c. A similar case is related by Mr. A. Reid.† More frequently we find loss of sensibility confined to particular parts; thus, numbness of the fingers is a common symptom of incipient paralysis. Sometimes pricking and tingling sensations occur, at others a feeling of creeping things on the part. These sensations may be confined to the hands or feet, or extend over the extremities, and occasionally occur in various parts of the cutaneous surface. Exaltation of sensibility may likewise take place, producing acute pain in particular parts, which is much increased on the slightest pressure. Mr. Travers‡ relates the case of a man who injured his back by a fall, and who felt the most agonizing pain in the lower extremities from the slightest touch, "to use his own words, when any one even walks by his bedside, it is just as if a number of razors were cutting him down to the bone."

The abolition of sensibility may take place on the whole side of the body, or may be confined to half the face, an arm, a leg, or both, or either of the superior or inferior extremities

* Medical and Surgical Journal, vol. 31, p. 292.

† Same Journal for April, 1829.

‡ Constitutional irritation, a further inquiry, &c. pp. 358-9.

may be simultaneously affected. Some rare cases have occurred where loss of sensibility has taken place on one side of the body, and loss of motion on the other. Dr. H. Ley* gives a case of this kind, which is quoted by Sir C. Bell. It was that of a woman who, after delivery, had defective sensibility on one side, and loss of motion on the other. She could hold her child to one breast as long as she looked at it, but on the attention being removed, the child was in danger of falling; on this side she could not feel the application of the child's mouth to the nipple, though she could see it sucking. On the other side feeling was entire; but she was unable to hold the child to the breast. Dr. Bright† also gives a case somewhat similar; and Andral mentions one of a man who had the right side of his face without sensibility, and the left without motion. Loss of motion has also been known to take place alone, without influencing the other functions. In these cases the limbs are generally flexed; a symptom which has been thought by Rostan indicative of softening of the brain; but it is not to be relied on. This function may likewise be increased, a circumstance daily brought under our observation in convulsions.

It most frequently happens, however, that both sensation and motion are affected together. This may depend on any kind of disease to which the cerebro-spinal system is liable. Extravasations have occurred into the anterior, middle, and posterior lobes of the brain, and produced the same symptoms, viz. hemiplegia of the opposite side. Whether the effusion takes place on the surface or in the internal parts; diffused or circumscribed, paralysis, either wholly or partially of the opposite side, is the result. Sometimes extravasation, to a small extent, will cause the most dangerous symptoms, while at others, when it occurs to a larger amount, they are by no means so alarming. It seldom happens that an extravasation takes place without producing paralysis; sometimes it causes convulsions, which gradually gives place to coma. On some occasions the patients feel headach, pricking sensations of the limbs, a

* Medical Gazette, vol. i. p. 755. † Bright's Reports, Case 271.

feeling of debility, and other premonitory symptoms; whilst on others the attack is sudden, and at once acquires its utmost violence, and then remains stationary or diminishes.

Ramollissement is another morbid condition of the brain which causes much disturbance to the sensific and motific functions; unlike extravasation, it is generally the result of a slow action. The facts we derive, however, from our observation of this change in cerebral structure, are the same, and as much opposed. Softening may occupy the whole of both hemispheres, or of one only; large portions may be affected on one or both sides; and on the other hand, the ramollissement may have extended a very short distance, including brain not larger than the size of a hazel nut; and yet, in this last instance, the symptoms may be as well marked as in the others.

Such are the contradictory results a record of cases produces; and which every one, reading carefully any treatise on the pathology of the brain, cannot but observe. It would be useless to refer to these in detail; for although a careful study of them may materially assist the practitioner in his treatment, they throw no light on the attempts of physiologists to ascribe to particular parts of the brain distinct functions. On the contrary, they are decidedly hostile to every hypothesis hitherto advanced. Many cases may indeed be adduced confirmatory of such and such opinions; but if as many others are also brought forward which tend to an opposite conclusion, all arguments based on the former must be nugatory.

Diseases of the brain likewise produce disturbance in the organs of special sensation. Thus, besides their perversion, which we have already mentioned as being connected with a deranged state of mind, double sight, and spectral illusions of various kinds, have been observed to usher in cerebral hæmorrhage. Andral mentions the case of a locksmith, who, having experienced dizziness of the head for eight days, suddenly lost his sight. After having remained blind for fifteen days, he suddenly fell down deprived of consciousness, and paralysed on

the right side. Consciousness soon returned, the hemiplegia continued, but he recovered his sight, which, however, always remained weak. He mentions another case where the sight was completely lost and again returned three separate times. Other cases have occurred where the sight has been improved, and vision rendered more acute under like circumstances. In cases of paralysis, where the sight has been affected, it has been lost entirely, or on one side only; and in this last case it may take place on the paralysed side or otherwise. Loss of vision, like the disturbance of general sensation or motion, seems to follow disease of no particular part of the brain. Flourens imagined it to be dependent on the cerebral hemispheres, and Serres on the optic thalami. But Andral says he has found alteration of vision dependent on lesion of all parts of the hemispheres. Disease of the cerebellum is sometimes accompanied by loss of vision, and the connection of this organ with the corpora quadrigemina by means of the *processus a cerebello ad testes* is supposed sufficiently explanatory of this fact. Hearing may also be affected before and after disease in various parts of the brain. In idiopathic inflammation of the dura mater, ear ache is a general symptom, and buzzing in the ears, tinglings, and total deafness often depend on disorganization of the cerebral substance. Taste and smell may also be impaired from a similar cause.

No fact is perhaps better established by experiment, than that wounds inflicted on the cerebellum, produce more or less loss of control over voluntary motion. If this organ be indeed the regulator of motion, as experiments performed on it would induce us to think, a diseased state of the cerebellum must cause more or less variation in the performance of this function. This is by no means always the case. Paralysis indeed often occurs in conjunction with diseased cerebellum, but it must be remembered that so it does also with almost every other part of diseased brain. Moreover, the cerebellum has often been extensively diseased without producing any effect on the motive powers. The conclusion we are able to arrive at from

an inspection of morbid cases, will be seen by examining eight cases of cerebellar disease detailed by Dr. Abercrombie.* (Cases 3, 13, 82, 83, 84, 85, 88, 89.) From this it will be seen that in four there was no aberration of motion, although in some the disorganization had proceeded to a considerable extent. In one where both lobes were diseased, there was an unsteadiness of motion, and inability to lay hold of anything. In another *both* arms and legs were spasmodically acted on, from a small tumour in the *left* hemisphere. In a third case, there was *slight* paralysis of the *right* arm and leg, where the *whole* of the *right* lobe was much softened. In the fourth, epilepsy and paraplegia arose from disease of both lobes. These cases exhibit the opposite effects disease of this organ produces. In the appendix of this same work, so much celebrated for accuracy, are described twelve cases of organic disease of the cerebellum, with their dissections. Of these, three exhibited no affection of motion whatever ; one had paraplegia ; one with headach, sometimes so severe as to oblige the patient to remain in one posture; one, walk unsteady ; three with convulsions before death, one of these with spasmodic action of the limbs; one, numbness of left hand; one, numbness of the right side, and one with constant motion from side to side.

In thirty-six cases mentioned by Andral, there were but eight, in which motion was not in some way disturbed. In these also sensation was equally affected. The works of Bright, Carswell, Hooper, Serres, Cruvelhier, and others, present also numerous cases in which we find extravasations into, and tumours, and softening of the cerebellum, all of a like nature to those already quoted, and which, although they generally have as a symptom paralysis, or convulsions, these are often well marked, and very violent from apparently trifling lesions, and are as often slight, when the whole or greater portions of the cerebellum has been completely disorganized. Cases of cerebellar disease also occur sufficiently

* On the Brain, &c. 3d edition.

often without disturbance of motion, to prove that this function cannot depend more on this portion of the encephalon, than on any other.

The effects observed by Magendie to arise from injury of the cerebellum, have seldom been seen to follow disease of that organ, however extensive. The same may be said respecting the corpora striata. Abercrombie* mentions two cases where both these bodies were diseased, only causing paralysis, in the same manner, as when other parts of the brain have undergone structural alteration. Cheyne† also describes two cases where both corpora striata had been injured by morbid action, yet the patients exhibited no desire to move forwards.

In the lower animals, particularly in the sheep, there has been noticed a disease named turnsick, characterized by a peculiar habit of turning round in one way, with the head twisted on the same side. As the disease advances, so does the rotatory motion, and they will continue to form concentric circles for hours together, until they fall exhausted. This is found to be occasioned in sheep by the existence of hydatids, either between the pia mater and brain, or imbedded in the cerebral substance. According to Youatt,‡ if hydatids are in both lobes, the head will be sometimes held on one side, sometimes on the other; if in the corpus callosum, or central parts of the brain, the sheep will march straight forward, with the head depressed, without the power of avoiding objects, and continually falling: if in the cerebellum or fourth ventricle, the muzzle will be elevated, and the head thrown back, while the sheep will run straight forward. The same disease occurs in cattle, but in them has been found to be occasioned by other causes, such for instance as compress the brain. Dogs also will describe circles for hours together, first, carefully avoiding obstacles, but by degrees the sense of vision becomes lost, and their mental faculties impaired, and then they strike

* Cases 31 and 43. † Cases 10 and 22.

‡ Supplement to Lectures in the Lancet, page 3.

against every impediment. In this last class of animals, hydatids have never been found, and in them the affection is dependent generally on spiculæ of bone, or effusions compressing the brain; in some few cases, however, no perceptible lesion has been discovered. That the human brain is subject to hydatids, has been much disputed by various pathologists. Cases where cysts have been found, are mentioned by Rostan,* and Headington.† By others, these are considered only as serous or vesicular cysts.‡ Although the origin of these bodies has given rise to many ingenious speculations, we shall not enter into the subject here, more particularly as we do not observe the same effects produced by them in man, as in the lower animals, and even in these the phenomena cannot be reconciled with the views of Magendie and others.

Bellingeri, in support of his doctrines regarding the seat of flexion and extension, has brought forward thirty-four cases, selected from the works of Morgagni, Lallemand, Bouillaud, Dan de la Vanterie, Avisard, Martin, Solon, Piedagnel, Hertin, and Serres. Of these, there are twenty-three in which, with symptoms of apoplexy or palsy, was connected a greater or less degree of flexion of the arms, or tetanic rigidity of the head and neck. These symptoms depended on disease or irritation of the hemispheres, principally confined to the optic thalami, corpora striata, posterior part of the ventricles, and the middle and posterior lobes. The remaining eleven cases, are those of cerebellar disease, causing different degrees of distension in the muscles of the head, trunk, and extremities. From these cases, in conjunction with the experiments and observations formerly noticed, he wishes it to be established, that one species of motion is produced by the brain, and an opposite one by the cerebellum. In the same manner he imagines the former to preside over adduction, and the latter over abduction. This is what he denominates nervous antagonism, by which he thinks all motions throughout the body

* Recherches, &c., chap. 10. Acephalocystes, p. 166.

† Med. and Surg. Jour., vol. xv. p. 504. ‡ See Hooper's 15th plate.

are governed. Thus opisthotonos, or spasmodic extension, depends according to him on some irritation or disease of the cerebellum, and posterior columns of the spinal cord; and emprosthotonos, or spasmodic flexion, is caused by morbid alteration in the hemispheres, or anterior roots of the spinal cord.

These views, although exceedingly ingenious, are no more susceptible of proof, than are the other speculations of physiologists, and are moreover opposed to a large number of facts. Mr. Travers observes,* "It is against the theory of Bellingeri that sensation is in no degree implicated in tetanus, whatever be the direction in which the spasms prevail, and especially that the acting power, whatever it be, is altogether preternatural which is employed to produce the involuntary contraction of muscles, in health obedient only to the will. If it were an excess or failure of natural action, we might expect a conformity in the natural structure, but it is an absolute perversion of healthy action, and therefore not illustrative of healthy conformation and function." That thirty-six cases should agree with his opinion, appears by no means surprising, when we read the list of authors from whose writings they are selected; but on contrasting them with the numbers which are opposed to this doctrine, it will be at once apparent, that pathology tends more to overthrow than support Bellingeri's hypothesis. Thus, though it has occasionally happened that flexion and extension are found as symptoms of certain diseased parts of the brain, there are numerous others where a great portion of the hemispheres and the cerebellum has been involved without any such symptom having been recorded—Andral mentions that three cases of *entire* softening of the cerebellum have come under his notice; of these only one favours Bellingeri's views.

Those causes which disturb the functions of sensation and motion in the brain, operate with the same result on the spinal marrow. Injuries of the spine have been followed by loss of motion, without loss of sensibility, and the contrary. Pott's

* Further inquiry concerning Constitutional Irritation, p. 338.

disease is often accompanied by paralysis of the lower extremities, and in such instances, motion is more frequently affected than sensation. Pott has shewn that this does not depend upon the curvature, as the paralysis often disappears, and leaves the curvature as it was. In this disease the bodies of the vertebræ are generally carious, and we should naturally expect that in accordance with the experiments of Sir C. Bell, loss of motion would take place, if the diseased action be communicated to the anterior columns of the spinal marrow. Should the disease extend, sensibility will become affected, and if a recovery takes place this property will return first. This is invariably found to occur. A case of Dr. Hunter's, related by Abercrombie, illustrates the effect produced by injury of a portion of the spinal marrow. A man was thrown down from a height of ten feet, and a month after the accident, was admitted into the wards of the Royal Infirmary, having with other symptoms, complete loss of motion of the lower extremities, without loss of feeling, and having all the muscles of the affected parts in a state of flaccidity. Inspection discovered extensive softening of the body of the cord, which affected chiefly the anterior columns. Ramollissement of the cord may, if confined only to the posterior columns, produce loss of sensibility alone, and we always find, if it extend to the whole substance of the cord, or pressure has acted on its entire thickness, both the sensibility and motion of the parts below the injury are destroyed. Several remarkable instances of paralysis have also occurred, with and without convulsions, where, after the most careful inspection, no morbid appearance could be found either in the brain or spinal marrow.

Diseases of the nerves have caused the same symptoms we have enumerated, as being dependent on diseased brain and spinal marrow. These convey impressions to and from the cerebro-spinal axis, and we may readily conceive that the sensibility and mobility of parts, may be more or less impaired according to the nerve affected.

From a survey of the facts and observations that have been noticed, and from a careful study of the details of numerous

experiments, and pathological dissections, we conclude that the various theories hitherto advanced are altogether untenable. How can we suppose that the different portions of the brain can undergo a cancerous and tubercular degeneration;—be compressed by the extravasation of fluids;—or their whole substance be completely disorganized by suppuration, or the process of ramollissement, without in any way affecting those functions ascribed to them by physiologists? We never hear of the other organs of the body, such as the heart, lungs, liver, &c. suffering such dreadful lesions, without producing more or less derangement in the functions they perform, and it would be contrary to the principles of reasoning to suppose that the nervous substance alone should under such circumstances be enabled to perform its offices. It has been said that the functions of the brain are double, and that they may be carried on if one half of the brain be sound, in the same manner that we can see with one eye, respire with one lung, and so on. But instances have occurred where *both* hemispheres, *both* lobes of the cerebellum, and *both* corpora striata have been diseased without their supposed functions having been disturbed. One authentic case of this nature would throw considerable doubts on the truth of any theory, however plausible, and that there are many such, the records of pathology sufficiently prove.

I have thus endeavoured to describe how complicated and apparently opposed are the physiological and pathological facts connected with sensation and motion. In the last part of this paper we shall endeavour to reconcile the contrarieties that have arisen on this subject, and shew the conclusions that may rationally be deduced from the facts mentioned in the foregoing pages. But before proceeding to this inquiry, we shall enter into a consideration of what physiology and pathology have taught us with respect to Intellect.

SECTION II.

OF INTELLIGENCE.

Experiments on the lower animals have contributed very little to the elucidation of mental power, the nature of which

is involved in as much obscurity as when it was subject to the unfounded speculations of heathen philosophers. These were of opinion that the viscera of the body, such as the heart, liver, spleen, bowels, &c. were the seats of the various mental faculties, or moral feelings,—an error that has been popularly transmitted to us in the writings of poets, and the remains of which may be still traced among the terms used in general conversation. A knowledge of anatomy and physiology however has shown that these only participate in the feelings and faculties through the nervous system, and that the brain is the sole seat of intelligence; but whether it is dependent on this organ generally, or only on particular parts of it, is not yet decided.

The principal knowledge we possess of the manifestations of mind are derived from our observation of the disturbance caused in it by disease, together with the result of pathological investigations. The former proves to us that intelligence may be affected in a variety of ways, when the latter have been followed by no appearances of diseased brain; and when disease has been discovered to a large extent, it is often doubtful how far the mental aberration is caused by it. It is also often difficult to distinguish whether the lesion which exists has caused the disturbance of mind only, or the death of the individual, or whether both effects depend on the one cause; for we find, in conjunction with insanity, almost every disease to which the human frame is subject, and very often apoplexy, epilepsy, paralysis, and those affections known to depend occasionally on a morbid condition of the brain. The difficulties and opposing facts, therefore, with which an investigation of the functions of sensation and motion were accompanied, are, from the complication thus existing, increased when an attempt is made to scrutinize the seat of intelligence. The intimate connexion, also, that subsists between the mind and the body, and the facility with which they act on each other, must considerably modify any conclusion we may be led to form concerning the influence of disease upon the mind. Thus we know that the most trifling changes in the system such as repletion or fatigue of body, a feeling of cold or heat, changes in the atmos-

phere, &c., will often for a time prevent any great exercise of the mental faculties. There are also few diseases of long continuance which do not impair the memory, and the most trifling injuries often produce an irritation sufficient to prevent all processes of thought, and occasionally even lead to delirium. The influence of the mind over the body is still better marked; thus, great exercise of the mental faculties produces disordered digestion; various emotions accelerate the action of the lungs, and increase that of the heart, together with the strength of the circulation; depressing passions have produced various diseases, and even death itself has been occasioned in individuals who have suddenly heard of afflicting intelligence. In addition to this, the mind can be influenced by all the diseases which produce derangements in the other functions of the brain, and this by no means in a uniform manner, so that the uncertain phenomena, which have been observed in connection with this function, renders extremely difficult the establishment of any opinion which assumes a distinct part of the brain as its seat.

Little is at present known concerning the intelligence of the lower animals. That many of them perform actions evidently the result of a reasoning process, is certain. Thus it has been observed, that a dog, on being shut up in a room, has rung the bell and escaped on the servants opening the door.* The extent, however, to which different animals carry their sagacity, and the various modifications of this function to be found among the numerous races, are quite unknown. We possess no means of discovering either whether their intelligence is affected in the same manner as that of man, or by the same causes; circumstances which do not apply to sensation and motion, and which, in a great measure, render nugatory the experiments that have been performed as far as they relate to the illustration of this function.

It has been observed by Flourens, Rolando, and others, that, on removing the cerebral lobes, the animals apparently suffer

* Jesse's Gleanings.

no pain, and the injury produces no disturbance of sensation or motion, but they become dull and stupid, and apparently lose all consciousness. Many remarkable cases of injury the human brain has sustained have been published, which shew that the hemispheres are quite insensible, and that they are not followed always by loss of intelligence. Sir C. Bell* mentions the case of a man who had received a pistol ball which had passed through the head. On forcing his finger deep into the wound (the patient being quite sensible) he complained only of the integument. In diseased states of the hemispheres, however, they often become acutely sensible, as is manifested by the excruciating headache that is produced, in the same manner that bone, though generally insensible, when inflamed, causes the utmost pain on receiving the slightest injury.

Many cases have been recorded where *corresponding* portions of both hemispheres have been destroyed to a large amount without affecting the intelligence. In the Edinburgh Medical and Surgical Journal† will be found the case of a man, aged twenty-two, in whose hands a gun exploded, causing the breech to penetrate the frontal bone above the superciliary ridges to the depth of an inch and a half, carrying with it a piece of bone three-fourths of an inch in diameter. He was found shortly after by his father perfectly sensible. The piece of iron and bone were afterwards removed by a surgeon; twenty-three days after the accident he was convalescent. Mr. Maunsall, who reports this case, says "It is quite certain a quantity of the substance of the brain was destroyed, and it is difficult to conceive that corresponding parts of both hemispheres did not share in the loss;" yet he was not able to detect the slightest alteration in mental power; "He pursues his usual avocations as formerly, attending to his farm, and occasionally weaving, and exhibits no appreciable deficiency in memory or acuteness of perception. Since his recovery he has been attending an evening school, and asserts that he finds no change in his capacity for acquiring knowledge."

* Anatomy, vol. ii.

† Vol. xliii. p. 76.

Dr. Abercrombie mentions the case of a young lady, who was subject, between her eighteenth and twenty-first years, to indistinctness of vision and irregular paroxysms of insensibility, with general muscular rigidity, but without convulsion. At the latter period her general health was much better, so much so that she married. Two months after, the vision was much improved; the paroxysms were suspended, "and her general health and spirits were such, that the evening before her death was spent cheerfully with a party in the house of a friend." She went to bed in her usual health, and at eight next morning was found dead. On inspection "the brain, externally, was found healthy, but when a thin section was cut from the upper part of the left hemisphere a cavity was exposed, through which a probe passed in every direction without any resistance through nearly the whole extent of the hemisphere." The whole of this hemisphere formed one great cyst, full of pultaceous matter, inclosed in a thin covering of healthy brain, which in many places did not exceed a quarter of an inch in thickness, and on the upper surface not more than one half or three quarters of an inch. *The right hemisphere had the inner part of the anterior lobe considerably softened.*"

A case is related by Dr. J. Johnson* of an eminent artist, who, for several years, had been subject to the most dazzling spectral images, the brightness of which was unspeakably distressing. The sight at length was totally destroyed, but "with the exception of some irritability of temper, there was not the slightest affection of the intellectual powers. The memory, the imagination, and the judgment were unimpaired. He was led about the streets by one of his servants; and he attended to all matters where his sight was not engaged, with the greatest punctuality." In the spring of 1835, he was seized with the usual symptoms of apoplexy. He lay in bed motionless and insensible, passing the urine and fœces involuntarily—the pupils dilated—and the power of speech gone. After a few weeks he was able to walk the city, and transact

* Medico-Chirurgical Review, vol. xxiv. p. 202, 1835-6.

business as usual—but the painful spectral images returned with increased intensity. In the month of August he was again seized with apoplexy, and died three or four days from the commencement of the attack. "The body was examined on the day after his death. There was nothing unusual in the membranes of the brain. The right lateral ventricle contained nearly two ounces of clear fluid. The left ventricle was occupied by a series of hydatid-like cysts of various sizes, and filled with fluids of various consistences and colours. This cluster sprang from the floor of the ventricle, by a kind of peduncle, and penetrated into every sinuosity of the cavity, pushing its branches anteriorly, so as to pass over and before, the thalamus nervi optici of that side, and even into the opposite hemisphere of the brain, destroying all the parts in its march. Both thalami were reduced to a pulp, as was indeed the *whole of the anterior lobes* of the brain, which would scarcely bear the slightest handling, without falling into a state of deliquescence. The optic nerves were pressed upon by the cystic hydatid mass, and reduced to a little more than the size of threads, and these of very soft consistence."

Dr. Bright* mentions a case of tetanus consequent upon a wound. The mind was not affected between the paroxysms. There was an irregular excavation on the anterior lobe of both hemispheres, in the same situation on each side, about the size of a shilling.

These cases, with others that might have been adduced, are decidedly opposed to the theory now so prevalent, which places the seat of intelligence in the anterior lobes.

The most complete loss of intelligence is occasioned by sudden pressure on the brain, and that pressure is the disturbing cause, is placed beyond doubt by the recovery of the function on this cause being removed; but if it take place gradually, no such effect is immediately produced. Thus, large tumours and abscesses may occur, which have considerably displaced portions of the brain, pushing parts of one hemisphere to the opposite side of the cranium; effusions of blood and serum

* Reports, Case 273.

may also take place slowly, causing large cavities in the cerebral substance, without producing mental disturbance. In these cases large portions of brain have been lost by interstitial absorption, a property which cerebral substance possesses in common with the other textures, and which prevents the effects of pressure. Thus, if the distension and pressure be gradually applied, the power of accommodation the brain possesses will prevent any great disturbance of the functions belonging to the healthy portion, until the disease has reached a certain extent, when its effects become manifested.

In some cases even when sudden pressure has been applied, this power of accommodation has caused one or more of the brain's functions to re-appear after having been lost for a short time ; and the following remarkable instance which came under my observation illustrates this : A musician became suddenly convulsed on board one of the Forth steamers, on recovering from which he was found to have paralysis of the lower extremities—loss of speech—when disturbed, tossing about of the arms, and violent motion of the head from side to side. The case book of Dr. Short, (under whose care he was admitted into the wards of the Royal Infirmary,) says, " he is quite sensible, and does what he is bid when spoken to," puts his tongue out when told, &c. He preserved his intelligence up to the moment of his death, which took place in the night of the day following the occurrence of the attack. On inspection, the two lateral ventricles were found much distended and filled with a mass of coagulated blood to the amount of three or four ounces on each side. The third and fourth ventricles were also filled with the coagulum, and it was traced through the fissure of Bichat to the spinal marrow, which it covered in its whole extent.

The records of pathology show that the intelligence is disturbed by the same causes that produce derangement of sensation and motion. We have mentioned some cases where it preserved its integrity when the disease was very extensive ; but, on the other hand, the application of apparently a slight cause is sufficient to occasion its complete destruction—after which it has sometimes happened that the intellectual faculties

are restored either wholly or in part. Occasionally the effect of disease is only to weaken the intelligence, causing partial loss of memory; incapability of expressing ideas with fluency; an appearance of stupor and dullness, the patients being quite capable when roused, of pursuing their usual avocations, but generally exhibiting great indolence. On other occasions disease may produce the utmost excitement of mind, giving rise frequently to paroxysms of delirium which may exist at the commencement, or come on at a later period—may continue a shorter or longer time, and return at various intervals.

Many pathologists assert that they could not trace any morbid appearance in several cases of persons who had died insane; whereas others maintain that this arises from superficial observation, and that mental derangement is always the result of organic change in some part of the cerebral substance. Esquirol* mentions, that, on the examination of the bodies of 277 insane persons, he found but 77 with disease of brain; Pinel† (the father,) but 68 out of 161; and Georget‡ was not able to find alteration of the brain's substance in one half of his insane cases. Haslam,§ on the other hand, describes 37 cases of insanity which he examined, in all of whom the membranes were unsound, except one. Marshall‖ gives 22 cases, in 21 of which serous fluid, varying in amount from one to twelve ounces, was effused into the cerebral cavities; and Mr. Lawrence,¶ who is surgeon to Bethlem Hospital, states, that he scarcely ever met with a case of insanity in which the brain was found entirely sound. Thus, one class of persons say that insanity is a disturbance of ideas only, or is a functional disease; while another party contend that it is always the result of organic changes in the brain or its membranes.

In support of the first opinion, it has been said that persons have completely recovered their reason, after remaining for some time insane; that on examining many persons who have died labouring under insanity, no disease of the brain or its

* Dict. des Sciences Med. vol. 3.
† Mag. Journ. vol. 6.
‡ De la Folie.
§ On Madness, &c.
‖ Morbid Anatomy of the Brain.
¶ On Man.

membranes has been discovered, and that the organic changes which have been observed in the brains of insane persons, have been found in others whose faculties remained perfect to the last. Though these propositions generally are correct, it does not follow, as is maintained by some, that insanity arises from mere moral causes; consists of disorder of the immaterial principle; is to be removed only by measures which operate on the intellectual faculties; and that the organic changes discovered after death are the effects, and not the cause of mental disorder. On the contrary, the supporters of the second opinion maintain, with equal truth, that mental derangement often arises from the same causes which produce numerous diseases, such as apoplexy, epilepsy, palsy, &c.; that decided cases of these disorders generally terminate in imbecility; that insanity is often periodical, connected with the alternate prevalence of inflammatory excitement and vascular debility, circumstances which increase or diminish the functions of all organs. Lastly, it is well known that insanity has followed various injuries of the brain, the repulsion of cutaneous eruptions, plethora, apoplexies, insolation, &c.

Arguing from the above facts, some are of opinion that organic change is the effect, others that it is the cause of insanity, and for the purpose of determining this question, have endeavoured to trace the origin of insanity to its source, and determine whether it be the result of moral or physical causes. The tables that have been drawn up for this purpose cannot be relied on. The reports are often fallacious, and it is often impossible to trace the origin of the disease. An individual may have his mind impaired for years without its being suspected, and to the circumstance (whether moral or physical determined by accident) which causes excitement is attributed the source of the malady.

Bayle is of opinion that insanity generally depends upon a chronic inflammation of the meninges. Several cases have been published tending to show that it arises from diseased sella turcica. Burrows states that it frequently arises from diseased liver; and others that it is occasioned by diseases of

the heart, lungs, abdominal viscera, &c. These last certainly may be remote causes, (for it is difficult to conceive how the brain can be directly influenced by them,) and may operate by producing general excitement of the system. Thus delirium is occasioned by fever, mania has been produced by sprains and fractures of the extremities, and in women affected with cancer, which has subsided on the removal of the irritating cause, in the same manner as traumatic tetanus has been cured by the amputation of the wounded leg.

Much addition has been made to our knowledge of the pathology of insanity by Foville, Delaye, and Pinel Grandchamp, who, in every instance, compared healthy brains with those which were the subject of examination. Indeed the extreme care and accuracy employed in their investigations, causes the facts ascertained by them to be of great value, and renders it probable that similar appearances, not having been observed by others, arises from the imperfect method of investigation generally employed. The result of extensive observation carried on in this way appears to be, that in all cases where the intellect is permanently affected, the cortical substance is diseased. In acute cases it is more red, often with bloody spots, and minute extravasation, being apparently the seat of active inflammation. In chronic cases there is an increase of firmness and density, extending to no great depth, but uniform, which may be torn off, leaving the layer below soft, and resembling granulations. Foville has never observed adhesion of the cortical substance to the membranes in recent cases, although in those that are chronic this is common, hence he explains how the former are more susceptible of cure. It often happened that there was atrophy of the convolutions confined to the grey matter. In extreme cases of insanity, as in dementia, the grey matter was found in a complete state of ramollissement, which might be either conjoined or not with structural change in the medullary portion; in the former case the dementia is conjoined with paralysis or marasmus. From these investigations he concludes that morbid changes in the cortical substance are directly connected

with intellectual derangement.* This opinion derives much support from numerous cases reported by Bouillaud† and Davidson,‡ who agree in the conclusion of Foville regarding the connexion of the cortical substance with the intellect.

Having now given an abstract of what is at present known on this subject, we shall proceed to explain the conclusions to which we have been led by an attentive consideration of the question.

PART II.

SECTION I.

ON THE PORTIONS OF THE NERVOUS SYSTEM MORE IMMEDIATELY CONNECTED WITH INTELLIGENCE, SENSATION, AND MOTION.

THE nervous system is universally allowed to furnish those conditions necessary for the manifestation of Intellect, Sensation, and Motion: but in what particular parts these are placed, or the limits assigned to each, are not determined. From the numerous facts collected, however, and more particularly from

* Dict. de Med. et Chir. Prat. Art. Aliénation.

† Traité Physiologique, &c.

‡ Medical Gazette, vol. ix. p. 664, et seq.

the circumstance that one of these may be lost without affecting the others, there can be little doubt that these important functions are situated in distinct portions of the cerebro-spinal system. In attempting to determine what particular part is connected with each respectively, it becomes important to remember that in no one single instance has it been known that mind was ever manifested without a brain, because this fact being universally admitted, we have succeeded in circumscribing the seat of intellect within the bounds of the cranium. Sensation and motion on the contrary, (which we must discriminate from irritability and contractility on the one hand, and consciousness and volition on the other,) remain perfect after the removal of a large portion of the brain, but cease on the destruction of the spinal marrow. We therefore conclude, that the principle on which sensation and motion depend, resides in this last portion of the cerebro-spinal axis, but that some part of the brain forms with it the seat of these functions.

In proceeding to examine what particular portions of the brain are more immediately connected with intelligence, sensation, and motion, it is necessary to attend to its structure as demonstrated by anatomists.

The structure of the cortical substance of the brain, is more vascular than the medullary, and is not fibrous but granular, although there is some slight appearance of fibres where it joins the white matter. It is not a simple layer, but consists of two strata, an internal and an external, the first $\frac{1}{50}$th, the last $\frac{9}{200}$th parts of an inch thick. Between these is interposed a stratum of white matter $\frac{5}{200}$ of an inch thick.

The circumstance of the cortical substance being differently arranged from other portions of nervous matter; being also more highly organized and delicate, would *a priori* lead to the conclusion that it is destined for some functions different from the rest; and it is an opinion supported by many physiologists, that it furnishes exclusively those conditions necessary for the performance of mental acts. This view may be presumed to be correct from the following facts :—

1. In the animal kingdom generally, a correspondence is

observed between the quantity of grey matter, depth of convolutions, &c. and the sagacity of the animal.

2. The results of experiments by Flourens, Rolando, and others, have shown, that on slicing away the brain, the animal becomes more dull and stupid, in proportion to the quantity of cortical substance removed.

3. Foville, Delaye, Pinel Grandchamp, Bouillaud, and Davidson, by an unusual degree of accuracy in pathological investigation, were always enabled to detect structural alterations of the cortical substance in cases of insanity; that is, by employing a degree of care which renders it probable that those cases recorded by writers where no alteration was discovered, depended on the unskilfulness of their attempts to demonstrate it.

4. An observation of the symptoms in those cases in which the disease has been afterwards found to commence at the circumference of the brain, and proceed towards the centre, shew that the mental faculties are affected *first*; whereas in those diseases which commence at the central parts of the organ, and proceeds towards the circumference they are affected *last*.

I am not aware that this last circumstance has been pointed out, it therefore requires some illustration. In meningitis the premonitory symptoms are languor, drowsiness, unwillingness to move, and inattention to the ordinary stimuli, although when roused these produce their usual effect. As the disease advances, excitement is occasioned, and delirium is produced. This may be more or less, or what is termed high or low delirium. In the former there is extreme pain with violent gesticulations and disorder of the motive functions, increased muscular strength, together with a rapid flow of ideas; in the latter, it is confined to muttering, with greater or less confusion of the intellectual faculties, and disregard of external stimuli. Lastly, coma follows, or complete loss of mind, attended also perhaps with loss of sensation and motion. But the opposite result follows in those cases where chronic abscesses, or softening, tumours or fungous growths, hydatids, &c. occur in the central portion, and gradually approach the circumfer-

ence. In these, disturbances of sensation and motion are first perceived, as starting in the sleep, spasms, convulsions, paralysis more or less complete, loss of sight and hearing (from pressure on the origins of the nerves,) and lastly, the intelligence becomes impaired.*

All these facts therefore, we think sufficient to warrant our considering the cortical substance of the brain the seat of intelligence; and when the circumstances to be noticed hereafter are taken into consideration, such as the peculiar liability of the brain to pressure, the nature of the circulation within the cranium, as well as constitutional differences, this view is capable of explaining, as far as can be explained, all the phenomena occasioned by the connexion of mind with any certain portion of structure.

In the first part of this paper it has been pointed out how numerous have been the opinions concerning the seat of sensation and motion. Bellingeri thought all that part of the brain above the corpus callosum was the mental,—that below it, the sensitive and motor; and it is now generally believed that the higher portions of the brain are connected with intelligence, and the lower more immediately with sensation and motion. Anatomists have lately pointed out the structure of the brain so distinctly, that we can proceed to decide the boundaries of each with a tolerable degree of certainty.

We are indebted for our knowledge of the fibrous structure of the brain, to Malpighi, Veussens, Reil, Gall, Spurzheim, Rolando, Blainville, Foville, and Bell. I shall for the most part follow the account given by the last, both because he is the latest author on this subject, and because I have verified the accuracy of his dissections by repeating them.

It is agreed by all, that below the medulla oblongata the posterior portion of the spinal cord is connected with sensation, the anterior with motion; that they both consist of fibres arranged in parallel lines, bound together by sheaths of

* As cases illustrative of this, I may allude to those given by Dr. Abercrombie, and Dr. J. Johnson, p. 48,—and two cases reported by Dr. Bright, Guy's Hospital Reports, vol. ii. p. 280, *et seq.*

cellular tissue. On tracing them downwards, they are found ultimately to unite, and form nerves which are ramified on the surface of the body, and partake both of the property of mobility, and that of sensibility. On tracing them upwards, Sir C. Bell found that both columns partially decussated, and then again proceeded upwards in regular lines. He found the posterior columns pass to the optic thalami, the anterior to the corpora striata. So far they were distinct and separate, but, from these bodies minute fibres were given off, which mingled together, and could be traced to the cortical substance where they terminated. Hence the sensitive and motor portions of the cerebro-spinal axis may be considered distinct from each other for a certain distance, and to terminate at either extremity, where they give off numerous fibres to be mingled with each other: this takes place superiorly from the opthalmic and striated bodies, and inferiorly where the spinal nerves come off internal to the vertebral canal. Anatomy, therefore, shows us that the sensitive column extends from the optic thalamus on each side, to the termination of the spinal cord, and the motor column from the striated bodies, also to the termination of the spinal marrow.*

This view is consonant with that generally held with regard to the functions of the superior and inferior portions of the brain, and may, I think, be supported by all the anatomical, physiological, and pathological facts with which we are at present acquainted. As regards the cerebellum, it has been shewn by Reil to consist of medullary fibres, and layers of grey matter similar to those observed in the cerebrum. Mr. Solly has lately demonstrated that it receives fibres from the anterior columns; an important fact, as it proves that this portion of the brain is composed of the same structures, and most likely performs the same functions, as the cerebrum†.

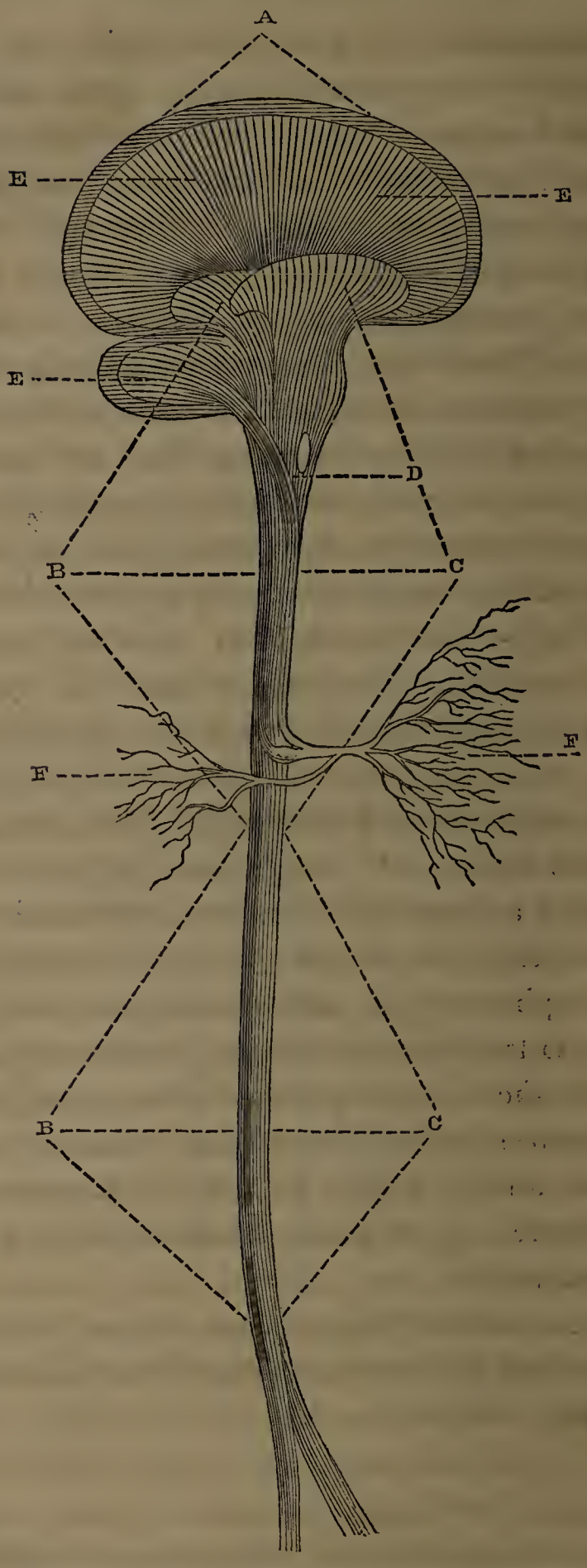
* Foville has pointed out the strong analogy existing between the central parts of the brain and spinal marrow. Phil. Mag. vol. v.

† On examining the 10th and 12th plates of Gall and Spurzheim's work, it will be seen that they delineate fibres passing from the anterior columns

I have thus stated what parts of the brain and spinal cord may be thought more immediately connected with intellect, sensation, and motion ; but it will be observed that there is another portion consisting of the medullary part of the brain, for which no function is ascribed. This it will be recollected is formed principally of fibres running between the cortical substance and the optic and striated bodies. In Dr. Alison's "Outlines of Physiology," there occurs the following passage —"It may naturally be inferred in most cases of voluntary actions, where the volitions exciting them are consequent on recollections and trains of thought, (however short) some physical change is transmitted downwards from the higher portions of the brain or cerebellum to the medulla oblongata, and determines the peculiar action there, by which the voluntary muscles are excited." This opinion may be considered correct, and it may be presumed that it is by means of the fibres forming the medullary portion of the brain, the influence of volition (a mental act) is transmitted from the grey matter to the corpora striata, and impressions made on the external organs of sense are conveyed from the optic thalami to what may be considered the mental portion of the brain. Those fibres running between the cortical substance and the corpora striata serve to transmit the influence of volition to the motor column, and those running between the optic thalami and cortical substance transmit impressions from the sensitive column to the mind, so that we may be conscious of them. I shall therefore, for the present, call them fibres of volition and consciousness.

The diagram will explain this subject still further. It represents a section of the brain, towards the outer side, while the spinal cord is entire.

into the cerebellum. Dr. Gordon states in his criticism on these plates, that such fibres have no existence in nature, and it is singular that the authors of the work should not have noticed their existence, though the artist did.



A. The cortical substance or mental portion.
B. B. The sensitive column. C. C. The motor column.
D. The passage of motor fibres to the cerebellum.
E. E. E. Fibres of volition and consciousness.
F. F. Sensitive and motor fibres.

It will be seen that in function a strong analogy exists between what I have called the fibres of volition and consciousness, and the nerves generally, composed of sensitive and motor fibres. It is well known that the latter have not any peculiar function themselves, but serve only to convey impressions made at their extremities. Injuries at various parts of their course only produce sensations which are referred to their ultimate distribution. Thus "if the inside of the elbow is accidentally struck against a projecting body, a peculiar tingling sensation is felt, not where the blow is inflicted, but where the ulnar nerve which has been struck terminates in the inside of the hand, and especially in the little finger. In like manner, an accidental pressure made for a few minutes on the popliteal space or sciatic nerve, will cause that peculiar tingling sensation in the foot, which is commonly described by saying that the foot is asleep, and which continues for some time after the pressure is taken away."* It has been found also, that on amputating the leg, when the nerves are divided, pain is felt as if in the foot.

As regards the fibres of volition and consciousness, we know that they may be lacerated, or otherwise injured to a considerable extent, without producing any particular effect. It will be remembered, that their office is to transmit sensitive impressions from the inferior parts to the cortical substance, and the influence of the will from the grey matter to the parts below. The effect, therefore, that we should expect to follow would be dullness of sensation, and incapability of voluntary motion. But it must be remembered that the mental part of the brain extends over a large surface, and we are as yet ignorant of what particular faculties reside in different portions of its superficies. The brain consists also of two symmetrical halves endowed with like functions; and another anatomical fact to which I have not yet alluded, shows that there are means for the transmission of nervous currents, (originating in trains of thought) from one hemisphere to the other, and

* Brodie on Local Nervous Affections, p. 3.

even from one convolution to others in the same hemisphere, without their being reflected from the sensitive and motor columns. Reil has pointed out that besides what have been called fibres of volition and consciousness, there are two other sets; one connecting together the near and remote parts of the cortical substance in the same hemisphere, the other running across from one hemisphere to the other, forming the different commissures.* Thus the mental portion possesses an apparatus which gives it peculiar facilities for transmitting the physical changes, or nervous currents, and we perceive there is an arrangement of fibres which somewhat explains that wonderful combination of the intellectual faculties, and those swift processes of thought which bid defiance to all attempts at analysis, and which it is impossible to follow.

The anatomical structure of the parts, therefore, in connexion with numerous physiological facts, afford strong reasons for believing that intelligence resides in the cortical substance of the brain; that sensation and motion more immediately depend on two distinct columns, the one commencing at the optic thalamus, the other at the corpus striatum, and both terminating where they unite inferiorly to form nerves: that the nerves consist of fibres, which convey the influence of impressions or nervous currents to and from the sensitive and motor columns; and that the medullary portion of the brain consists of fibres, which also transmit nervous currents arising from mental operations to and from the cortical substance, together with other fibres which perform the same office between one hemisphere and the other, or different convolutions in the same hemisphere.

Before entering into a consideration of how far the views proposed are consistent with the physiological and pathological facts brought forward in the first part of this Essay, it will be necessary to inquire what is generally understood by sensa-

* This opinion also was adopted by Gall and Spurzheim, but is partly denied by Foville, who does not consider the corpus callosum a commissure of the cerebrum, but as a plain derived solely from the crura, and therefore forming a commissure between them alone.

tion and motion. Metaphysicians consider that there can be no sensation without consciousness, and that the numerous impressions of which we are generally thought to be unconscious, arises from the circumstance that they are retained in the mind so short a period as to be immediately forgotten. Physiologists also have invariably believed sensation to be seated in some part of the brain, and have adopted the same definition. It is now, however, decided that associated movements for particular purposes, result from impressions in those animals who possess a spinal cord merely, and even in the higher animals, when the brain is removed. "Consciousness," according to Dr. Reid, is an operation of its own kind, and cannot be logically defined. The objects of it are our present pains, our pleasures, our hopes, our fears, our desires, our doubts, our thoughts of every kind, "in a word, all the passions, and all the actions and operations of our own minds while they are present." Dr. Brown does not consider it a distinct faculty of mind, he says,* "In the whole series of states of the mind then, whatever the individual momentary successive states may be, I give the name of our consciousness, using that term not to express any new state additional to the whole series, but merely as a short mode of expressing the wide variety of our feelings, in the same manner as I use any other generic word for expressing briefly the individual varieties comprehended under it."

These extracts are sufficient to show that consciousness cannot be separated from mind. Now the mind is universally allowed to be connected with brain alone; if therefore, the same sensitive phenomena are produced independent of brain, as when it is present, we must believe either that consciousness resides in the spinal marrow, or that consciousness is not essential to the performance of these actions any more than volition is. The so named sensations producing these, appear to me analogous to the involuntary motions of voluntary muscles; and the difficulty connected with this subject might be got rid of, if we consider sensation a function dependent on a portion of the cerebro-

* Lecture XI. on Consciousness.

spinal axis, in the same manner as motion is a function seated in another part of the same organ; that they may both be exercised independent of mind, and yet are connected with it; but that as motion originates from the centre, while sensation is caused by impressions applied to the circumference, so volition may be one of the causes producing the exercise of the first, and consciousness one of the results occasioned by the latter.

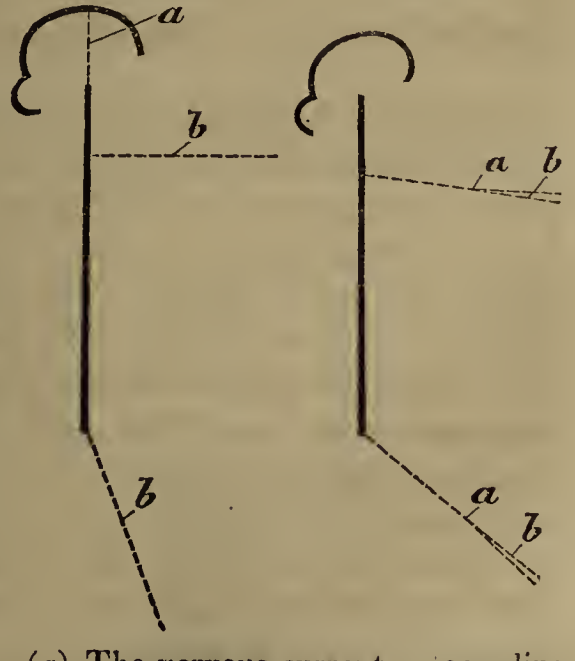
It is obvious, however, that this view alters the meaning of the word sensation as it is at present received, and this is if possible to be avoided. It becomes necessary, therefore, to employ some new term to express those movements which are performed independent of mind, and which, *therefore*, are not connected with sensation. Dr. M. Hall has called them excito-motory, and has performed several experiments to show that they are *spinal* only, which are of the same nature as those previously brought forward by Sir G. Blane, and Le Gallois. This term is a sufficiently good one to express those movements which are independent of volition and consciousness, but unfortunately it has been applied only to a new system, or arrangement of nerves which he wishes to establish; in this he appears to have gone too far, as may I think be proved from the following considerations of the nature and causes of motion.

All animal motions are occasioned by stimuli acting on muscular contractility. These stimuli may be classed under two heads; first, the stimulus of volition; second, the stimuli of chemical and mechanical agents. The former acts on a certain number of muscles only, the latter are capable of causing contraction in every kind of muscular fibre, and are the habitual and sole excitors of motion in those muscles necessary for the performance of the organic functions. Motion, therefore, may be excited in two ways, by volition, and the external or internal application of chemical and mechanical stimuli. This has given rise to the terms voluntary and involuntary motions; the only difference between them being, that the former may be produced not only by chemical and mechanical stimuli, but

by the influence of the mind, which the latter can not. But it must be remembered that what are termed voluntary muscles, often act independently of the will, on some occasions are thrown into violent contractions in opposition to its mandates, while at others the will may be exerted to cause motions and produce no effect. Thus, spasm may be produced by the sudden application of a hot iron to the skin, the prick of a sharp instrument, &c.; or convulsions, be occasioned by irritation applied to any part of the sensitive and motor column.*

It is to this last class of phenomena that Dr. M. Hall applies the term "Excito-Motory." He considers that they are produced by means of a reflex function,—this must be admitted, as the motor and sensitive filaments continue separate from their origin to their ultimate distribution. The difference between these and voluntary actions is, that, in the former, the impression is made on a sensitive nervous filament, the influence of which is reflected to a motor filament; whereas, in voluntary motions, the impression having been made, its influence is conveyed to the part acted on by means of the same filament throughout. Thus, in Fig. 1, volition arising in the cortical substance, is transmitted by a filament (*a*) to the motor column, and by means of the continuation of that filament (*b*) is sent to the muscles:—whereas, in Fig. 2, the impression made on the sensitive fibres at the outer extremity of the nerves, is conveyed by a sensitive filament (*a*) to the sensitive column, and reflected to a motor filament, (*b*) and so reaches the part acted on. In the one case, the conductor is perfect, in the

Fig. 1. *Fig.* 2.



(*a*) The nervous current, proceeding to, (*b*) that coming from the spinal chord.

* We observe continued involuntary movements in the heart, intestines

other broken. Probably the grey matter in connexion with the sensitive and motor columns bears a strong analogy to the inner layer of the brain's cortical substance, as it lies in immediate contact with the sensitive and motor filaments, and the reflex action must be conveyed through it.

Professor Müller* states that the brain also possesses this function, as shown by a vivid light and loud sounds producing reflected excitation of those parts supplied by the oculo-motor, and facial nerves, causing contractions of the iris, closure of the eyelids, &c. The same effects may be occasioned by applying stimuli to the extremities of the fifth in the face. Dr. M. Hall, however, considers all these actions spinal, and as the fifth and seventh may be traced to the spinal cord, he is so far right; the optic and oculo-motor, however, can not; and it would be therefore necessary to show that movements of the iris are not caused by the latter nerve, a point which the experiments of Mayo have established.

Physiologists are certainly much indebted to Dr. M. Hall for having clearly established this reflex function, and pointed out more accurately than had been done previously, the nature of those movements formerly denominated instinctive, sympathetic, &c. But if the views now advanced be admit-

and those viscera supplied by the sympathetic system of nerves. These, instead of being connected with any particular part of the cerebro spinal system, are dependent on it as a whole, and are fortunately placed beyond those disturbing causes to which voluntary motion is subject, and are influenced by it only indirectly. The stimuli which excite these motions are applied to the internal surface of the muscles themselves, and act mechanically. Thus, blood is the habitual stimulus to the heart's movement, food to the contractile power of the stomach, intestines, &c. These substances, therefore, stimulate the muscular fibres of these viscera mechanically, in the same manner as the prick of a pin would do, so that they differ from voluntary movements, merely by acting at all times independently of the will.

The internal sensations, like the involuntary motions of the hollow viscera, are connected with the sympathetic system of nerves. Little is known regarding them, although we may suppose they are "continually, though secretly, influencing the condition of the whole nervous system, and often to be the cause of remote morbid actions."—*Macartney, Report of Brit. Assoc.* 1834.

* Philosophical Magazine, vol. x.

ted, we must consider this reflex function as residing in the sensitive and motor columns, as they have been described, page 59, which will reconcile the difference existing between Dr. M. Hall and Professor Müller, and explain on the principles pointed out by the former, all the facts connected with this subject. It must also be considered, that these particular motions are in no way peculiar in their nature, or dependent on a distinct system of nerves, but that they are excited in the same manner, and act by the same means, as other involuntary motions,—that is, by stimuli applied to the sensitive column, either directly or indirectly, producing motion by reflecting the excitement so occasioned to the motor column, and from thence to the muscles.* In other words, as stated by a late reviewer,† these actions which are said to be chiefly connected with the sphincters, &c. differ in *degree*, not in *kind*, from involuntary movements generally.

The same reviewer‡ has also stated what deserves some slight consideration, viz.—that these movements, called by Dr. M. Hall excito-motory, are the same as the sympathetic actions of Whytt and Monro. They appear to differ, however, so far, that the one kind are excited most readily when the mind is absent, whereas in the other some mental feeling must necessarily intervene: while they are entirely prevented or suspended when the attention is strongly engaged. Thus the sudden contact of hot or cold bodies to the skin, prick of a pin, &c.,

* The following passage by Professor Müller, explains how this is accomplished: "As soon as the sensitive motion has reached the spinal marrow, it does not pass over the whole spinal marrow, but most easily to those motor nerves which have their origin nearest to the stimulated sensitive nerves; or, in other words, the easiest way for the current or vibration, is from the posterior root of a nerve or some of its primitive filaments to its anterior root, or to the anterior roots of several adjacent nerves. We see thus that the nervous principle in these currents or vibrations takes the shortest way, acting from sensitive fibres through the medulla spinalis or motor fibres; just as electricity takes the shortest way from one pole to the other." *Phil. Mag.* vol. x. p. 190.

† British and Foreign Medical Review, No. 5.

‡ It has been stated by Dr. Hall, in his Principles of Medicine, that Dr. Alison wrote the review alluded to.

if unexpected, will cause starting; but if a resolution be formed not to do so, this effect may be prevented. The mind exercises an influence over different muscles in different degrees; it also differs in various persons according to constitutional varieties. I have often seen the actual cautery applied as a counter-irritant in diseased joints; some, who resolve to bear the pain, do not move; while others, who look equally robust, cannot command themselves, and struggle violently. This modifying influence of the mind also is well seen in some American Indians, whose feelings of pride prevent their shrinking under the most excruciating tortures. The sympathetic actions of Whytt, on the contrary, instead of being induced, are arrested, or altogether prevented, by withdrawing the attention. This will appear, from the following passage in Dr. Alison's paper:* "The actions of hiccupping or sneezing, when just commencing, may very often be stopt by any thing that forcibly arrests the attention, as by calling out the name of the person. Dr. Whytt says, he had found a fit of hiccupping to be stopt by the effort of attention required in looking for two or three minutes on an object so small as hardly to be distinctly seen, such as the impression on a small coin. Every one must have observed how easily a fit of laughter, produced by the sense of tickling, may be stopt by a new emotion being excited, as by a loud sound, or the entrance of a stranger."† It is certain that this class of

* Med Chir. Trans. Edin., vol. ii., p. 178.

† And again,—"Many persons may be observed to sigh deeply immediately on finishing the reading of an interesting story, or hearing the termination of an interesting speech, to which they had been listening with what may literally be called breathless attention. Every one must have observed the coughing and sneezing which in a crowded assembly, in a winter day, infallibly succeed the profound silence occasioned by a speech of uncommon brilliancy and interest, and which imply that the causes of the sensations preceding these actions had existed for some time in many of the audience, but the sensations having been overpowered by other and more predominant feelings, their natural consequences had been suspended, until these feelings had in some measure subsided, and allowed the irritations in the air passages to become objects of attention to the mind."—p. 179.

actions cannot be produced without mind. Laughter cannot be caused by tickling an animal when the brain is removed, or sneezing or hiccupping. The stimuli which excite these are conveyed to the mental part of the brain, and by means of the reflex function it also possesses, reflected back before these effects can be produced. This is not necessary in the excito-motory actions.

It may be concluded, therefore, that there are only two kinds of motion, voluntary and involuntary, the former arising from the stimulus of volition, the latter from that of chemical or mechanical stimuli; and that the excito-motory movements of Dr. M. Hall are only involuntary motions, but more readily excited in some muscles than in others.

The principle conclusions arrived at, may be shortly summed up, as follows:—

1. The cortical substance of the brain furnishes the conditions necessary for mental acts.

2. The medullary portion is formed of three sets of fibres, and serves merely to conduct the influence of stimuli.

> The first set transmit the influence of volition from, and the result of impressions on the external organs of sense, to the cortical substance,—so that we become conscious of such impressions. Hence, they may be called the fibres of volition and consciousness.
>
> The second set connect together the two hemispheres of the brain, and convey the influence caused by mental changes from one to the other.
>
> The third set perform a similar office with regard to different parts of the same hemispheres.

3. Sensation, as it is at present understood by physiologists, expresses two things:—1*st*, That the influence of a stimulus has been conveyed to the sensitive column. 2*dly*, That this influence has been continued on through the fibres of the medullary portion of the brain to the cortical substance. In other words, we must be conscious of the impression that has been made, in order to produce a sensation.

4. The sensitive column commences superiorly with the optic thalamus on each side, forms the *posterior* part of the medulla oblongata and spinal cord, and terminates where the nerves are given off inferiorly.

5. The motor column commences superiorly with the corpus striatum on each side, forms the *anterior* part of the medulla oblongata and spinal cord, and terminates where nerves are given off inferiorly.

6. All associated movements are either voluntary or involuntary.

Voluntary movements are excited by a mental stimulus arising in the cortical substance of the brain, which is transmitted to the motor column by the fibres of volition, and continued forward to the muscles moved.

Involuntary associated movements are excited by chemical or mechanical stimuli, which are conveyed to the sensitive column, by the sensitive fibres in the nerves, and reflected to the motor column, whose filaments transmit them to the muscles acted on.

From this it follows that,

7. Voluntary and involuntary associated movements are occasioned by stimuli, the influence of which is conveyed by nervous fibres to the part acted on,—but that, in the one case, the stimulus is mental, in the other chemical or mechanical.

The movements termed Excito-Motory are of the latter class.

SECTION II.

EXPLANATION OF PHYSIOLOGICAL AND PATHOLOGICAL PHENOMENA BY THE VIEWS ADVANCED.

The numerous and apparently contradictory facts, brought forward in the first part of this Essay, may, I think, all be explained, and for the most part reconciled, by the views now advocated. They will also furnish other arguments in its support.

The experiments which have been made on living animals,

although very curious in their results, appear to be of little value in determining the functions of each portion of the brain; and when we see them so directly opposed to the facts developed by pathology, we must attribute the discrepancy to numerous sources of error, which originate in the method of operating. Thus removing the cranium, or a portion of it, a preliminary step in these vivisections is alone sufficient to destroy that equilibrium of circulation on which the healthy state of the brain depends; while the most expert experimenters are unable to prevent hæmorrhage, which in so delicate an organ must assist in producing results that cannot be calculated on. When, however, the same result is derived from well performed experiments, as we deduce from observations of pathological phenomena, it tends to confirm the views drawn from either; and if to this, anatomy reveals such connexions as will warrant and bear out such conclusions, we may consider that every proof is given which conviction requires. In general, however, experiment is opposed to both the other methods of inquiry, and is, from the causes pointed out, to be distrusted; and we therefore hold, that when pathology and anatomy unite to explain an effect, we are bound, if these are always uniform, to consider them sufficient, more particularly when we remember that lesions produced by disease (although their limits are often difficult to be defined) produce results which are not liable to such violent objections, and are, therefore, much more worthy of confidence.

The three functions of the brain which we are considering, although in their nature and effects different, appear to be connected with the portions of the nervous mass on which they depend, in the same manner. They are all capable of being perverted, increased, and diminished by the same external or internal stimuli, or by the same morbid actions. In observing the effects of these, it must be remembered that the brain is influenced by them in a very different manner, and more directly than any other organ of the body. Its substance is incompressible, and it entirely fills an unyielding case of bone, so that the slightest pressure will occasion interruption of its

functions; the proper performance of which depends upon a just balance of the circulation between the arterial and venous systems. Thus the application of a stimulus produces irritation, this causes excitement of the part to which it is applied, and the effect will be, an increase of the functions dependent on that part. If, on the other hand, instead of irritation, destruction of the part be occasioned, or sufficient pressure made on it, instead of an augmentation, a cessation of the particular function will ensue.

Any thing that tends to disturb the equilibrium of the circulation within the cranium produces these different effects, and they will be more or less marked, according to the degree of disturbance occasioned. Irregularity in the heart's action is the most frequent cause of this; and it may be occasioned by any of the numerous circumstances that are known to influence it, such as the variations in temperature, diseased action, use of stimulating food, alcohol, &c. An increased circulation of blood produces a rapid flow of ideas, sometimes delirium, attended with tinnitus aurium, and other disturbances of sensation, augmented muscular action, convulsions, &c. If it continues, or becomes greater, profound coma, or a loss of these functions follow. A diminution of blood is known to occasion the same results, convulsions, various disturbances of sensation and intellect, terminating in syncope, or a suspension of the brain's functions. Hence arise two methods of treatment in diseases of the nervous system, the antiphlogistic and stimulant, the latter only lately introduced by Abercrombie,* M. Hall,† and others. These physicians have shewn, that some forms of apoplexy, epilepsy, hysteria, &c. depend on plethora, while others are occasioned by a debilitated state of the system. One is cured by depletion, the other by tonics; and no circumstance more strongly exhibits the connexion between the practice and theory of our profession than this. The intelligence is influenced by exactly the same causes, and becomes disordered, from an increase or

* On the brain. † On bloodletting.

diminution of the natural stimuli. Excesses in diet and drink produce mania, and the same effect has been occasioned among the stranded sailors of the Medusa, and the ill fed peasants in some districts of Lombardy.

But the nervous system generally, and brain in particular, is liable to constitutional differences, or structural varieties, as well as other organs of the body; and we should not feel surprised that every individual is not affected in the same manner by changes in the circulation. There cannot be more than a certain quantity of blood within the cranium at once; but the balance between the arterial and venous systems may be altered in various portions of the brain's substance. Thus in some persons it produces ocular spectra, in others tinnitus aurium; in one the intellect may be principally affected, in another convulsions may be produced, or an increased degree of sensitiveness.

The circumstances now stated affect equally all the functions of the brain. It has been already mentioned, that each of these may be perverted, increased, or diminished, by the same causes. In those affections which produce disturbance of the mental powers, we may generally distinguish three stages. The symptoms in the first are, a sense of weight in the head, drowsiness, vertigo, &c.; in the second, delirium, a rapid flow of ideas, terminating in, thirdly, coma. The first is probably occasioned by the vessels changing their relative capacity in the cortical substance. As the disease progresses, the flow of blood becomes more rapid, the mental portion of the brain becomes irritated, and delirium or augmented action is the result. As the disease advances, the vessels become dilated, and a certain degree of pressure is produced; if this is sufficiently great, coma is occasioned. This may occur at once from sudden great pressure, or destruction of parts; but if the disease proceed slowly, the different effects I have described may be observed in succession.

The numerous varieties of hallucination depend on the constitution, habit of mind, external circumstances, &c. of the patient, and possibly on the part of the brain affected. But

all writers have admitted the existence of three distinct classes of insanity. 1st, A degree of madness analogous to the incipient stage of nervous diseases generally, characterized by a change in the ordinary pursuits of the individual, who is more or less eccentric in his habits. The mental faculties are not injured; when roused the patient is found to possess his usual intelligence, but he is generally gloomy, reserved, and inactive. The second class simulates the delirium from disease, and there is excitement. It is known by the great mental disorder, the ideas follow each other with great rapidity, and without connexion. It is now also that the motor and sensitive tracts participate in the affection. Sometimes there is diminished sensibility, at others it is augmented. There is generally great activity of the motor organs, and the strength of the individual is often much increased. Lastly, Fatuity, or a total loss of mind, follows these two stages, and here the motor and sensitive columns have become more affected, and general paralysis is often the result. These advanced cases, therefore, closely resemble the coma of disease.

A disturbance of circulation, or irritation, causes the same functional changes in the sensitive column as in that possessing intelligence. It is perverted, increased, or destroyed, by the same means. An increase of sensibility causes pain, which is a wise provision of nature, and in a healthy state of the nervous system recalls consciousness; but when a morbid action is going on in the intellectual portion of the brain, the individual is often insensible to the strongest impressions. Destruction by accident or disease, or strong pressure, occasions total loss of sensation, and this may occur without the intelligence or motion being affected.

Motion follows the same law; external or internal irritation of the motor column produces spasms and convulsions, or excessive action more or less well marked. Even when the intellectual faculties are suspended, and volition therefore destroyed, the same results follow, shewing that it is independent of mind. But pressure on, or actual disease of that portion of the motor column, either within or without the cranium, to

such an extent as will not only cause irritation but destruction, prevents this function from being called into action. Thus in cases of paralysis, although muscular contractility remains, external stimuli fail to produce flexion of the limb affected, and volition may be exerted with the same want of success.*

We see, therefore, that incipient disease, or irritation by means of moderate or partial pressure on any portion of the nervous system more immediately connected with intelligence, sensation, and motion, will produce excitement of that part, followed by an increased or augmented action ; but that complete pressure, or destruction of the part on which each respectively depends, causes total loss of either.

When any part of the motor or sensitive tracts have been destroyed, a loss of their function follows in the portion below. This may arise from pressure, or disease affecting the whole diameter of the tract. It has been observed, that ramollissement has involved a great portion of the spinal cord, or has existed in some part of the tract within the cranium, or hæmorrhage has taken place in the latter situation without the usual effect being produced. It will be found, however, that in such cases which have been carefully examined, the whole thickness of the tract has not been affected. Mayo noticed, that a very thin portion was sufficient to preserve the nervous influence, if it remained sound. As the tracts diverge within the cranium, there is less liability here for the whole diameter to be involved ; hence why we meet with cases of large chronic abscess in the cerebral lobes, disease of the corpora striata, &c. without producing disturbance, and others where death has taken place, and contrary to all expectation, the brain has been found extensively diseased. But all injuries of that portion of the tract in which the fibres are converged, and concentrated are followed by more marked effects ; hence the fatal and immediate result of lesions in the pons varolii and medulla oblongata.

In the brain, an organ so extremely delicate, whose integrity

* I must refer to Part I. for numerous facts connected with a disturbance of sensation and motion.

is so easily disturbed, the parts forming which are so intimately connected, and capable of influencing each other, it ought not to cause surprise that the same effect is produced from lesion of different parts of its substance, or that injury of the same part may occasionally cause different results. It is this circumstance, however, which has hitherto prevented pathologists from ascribing to different parts of the brain distinct functions, and has thrown so much confusion and apparent contradiction on the study of this subject. The structural anatomy which I have shewn to exist, will however reconcile all the facts that have hitherto been considered as opposed to each other. Thus an effusion into the anterior lobe of the cerebrum may cause more or less paralysis. Now no sudden effusion of blood can take place in any part within the cranium, without causing a greater or less degree of pressure; and it will naturally act on the nearest portion of the sensitive and motor tract. Supposing the corpora striata to be the seat of effusion, these we know terminate the motor tracts within the cranium, and some disturbance of motion we should expect to follow; but from the close approximation of the sensitive tract we could not suppose it would altogether escape: hence why it is so general that sensation and motion are disturbed together. Cases have been pointed out, however, previously, where one is affected without the other, or where sometimes one, sometimes the other, is injured in various degrees, from a total suspension, to the most undefined feelings of numbness, or partial loss of mobility. This obviously depends on the greater or less degree of pressure made on the different tracts, or in other words, the degree to which they are affected either directly or indirectly by the lesion. Again, hemorrhage may take place in the cerebellum, the pressure then would be exerted on the medulla oblongata, where the different columns are concentrated, and where we should expect well marked effects to follow.*

* An interesting case, strongly corroborative of the truth of these observations, is recorded by Davies Gilbert, Esq. formerly president of the Royal Society of London. It was that of a female who reached her seven-

The explanation now offered points out the reason why partial affections of the brain, if continued, become general, and why an injury of one function leads to destruction of the rest, at once explains why lesion of different parts of the brain should cause the same results, and exposes the fallacy of the reasoning that placed the seat of motion—by some in the cerebellum, by others in the corpora striata, while another part acted as a regulator, keeping it in order.

It has been observed by all pathologists, that the same train of symptoms has been caused not only by different degrees of intensity in the same disease, but by the various diseases to which the brain is liable. Now as the morbid appearances observed after death are so different, although they give rise to the same symptoms during life, we cannot ascribe these to the nature of the diseased structure, but must attribute them to something which all these changes have in common; and it appears to me that they all act in one of two ways, either of which are sufficient to produce the morbid phenomena; 1st, Pressure with or without organic change; 2d, Destruction of the part by disease, on which one or more of the brain's functions depend.

teenth year without having ever betrayed signs of external sensation or voluntary motion. At an early period of her life she had convulsions. "Though she originally gave indications of sight, blindness came on, and cataract was observed in the eye. The sense of hearing, if it existed at all, was very obtuse; latterly it was impossible to doubt that she was quite deaf. The sense of taste seemed to be tolerably perfect, as fruit, confections, &c. were received with indications of pleasure."—"On removing the brain from the basis of the skull, so as to expose the nerves, they all appeared firm and healthy. But in the base of the skull itself not a vestige of dura mater was to be seen. The place was supplied by a thin transparent membrane, very lax and irregular, so that it afforded no protection to the nerves in their exit from the skull. On the back part, likewise, the whole, or the greater part of the tentorium was deficient, thus allowing the whole weight of the brain to act on the cerebellum."—*Med. Gazette*, vol. i. p. 562. In this case there can be no doubt that external sensation and voluntary motion were lost, by the nerves being pressed on by the mass of the brain, as they passed through their separate foramina, while the fibres of volition and consciousness being also affected, the mind had lost all connexion with the parts below.

Pressure, I have already said, is occasioned by a change in the circulation; and in many cases where organic alterations have been discovered, it is presumable that these do not act merely by their presence, but because they render the brain more irritable, and more likely to be affected by such causes as produce disturbance of the circulation. Thus it has always been noticed, that convulsions, epilepsy, insanity, &c. are generally excited by the abuse of alcohol, the passions, commencement of fevers, exanthematic eruptions, puerperal disease in the female, and indeed all affections causing great constitutional disturbance.

Were it possible so to regulate pressure or organic change, that the mental portion of the brain might alone be influenced, delirium, coma, and mental derangement might be produced, without affecting motion or sensation. In this case there would be no disposition to move, but spasmodic action might be induced by the application of stimuli. In like manner were it possible to circumscribe pressure or disease to the motor or sensitive tracts, we might cause loss of motion without loss of sensation, or convulsion and paralysis, while the mental faculties and sensibility remained perfect. In some rare instances this is the case; but the gradual manner in which the various portions of the brain are lost in each other, together with their proximity, and consequent liability of partaking in disease, sufficiently explains why in the generality of cases impairment of motion, sensation, and intellect, are more or less produced together.

I cannot conclude without remarking, that our knowledge of the nervous system has now made such rapid progress, that the nomenclature connected with it requires revision and alteration. The student is confused by the different meanings applied to the same words, the immense number of theories advanced, and the numerous circumstances it is necessary to take into account before the most simple effect can be satisfactorily explained. Those also whose knowledge keeps pace with the progress of science, must see the inconsistency of

many terms in general use; and the difficulty of expressing *concisely* the various actions attributed to different portions of the nervous system. I am conscious, however, that this great revolution in physiology, is not to be accomplished by any feeble efforts of mine. It requires some mighty magician, whose wand is sufficiently powerful to break through the chains that time and custom have placed around this beautiful study; whose penetration is able to detect the fallacies and unfounded speculations with which it is encumbered; and whose genius and intellectual superiority will enable him to arrange the heterogeneous materials now collected, into a perfect system, and connect with it a terminology that will not only apply to the past and present knowledge of physiologists, but to whatever future discoveries may be made in this rich and inexhaustible field of inquiry.